Technical Report HL-96-4
July 1996

US Army Corps of Engineers
Waterways Experiment Station

Loosahatchie-Memphis Reach, Lower Mississippi River

Hydraulic Model Investigation

by Charles R. Nickles

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Prepared for U.S. Army Engineer District, Memphis

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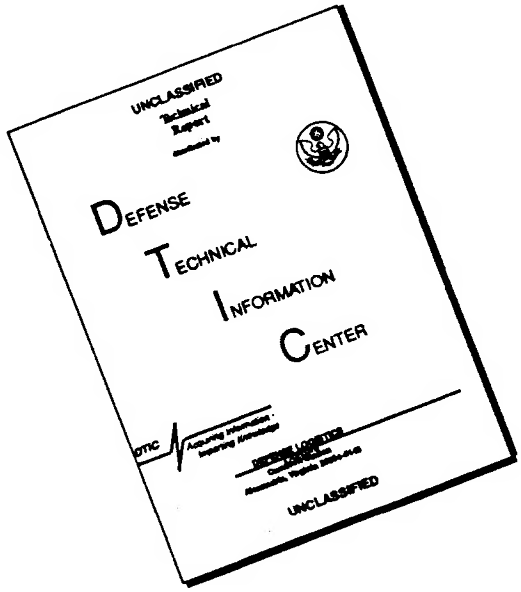

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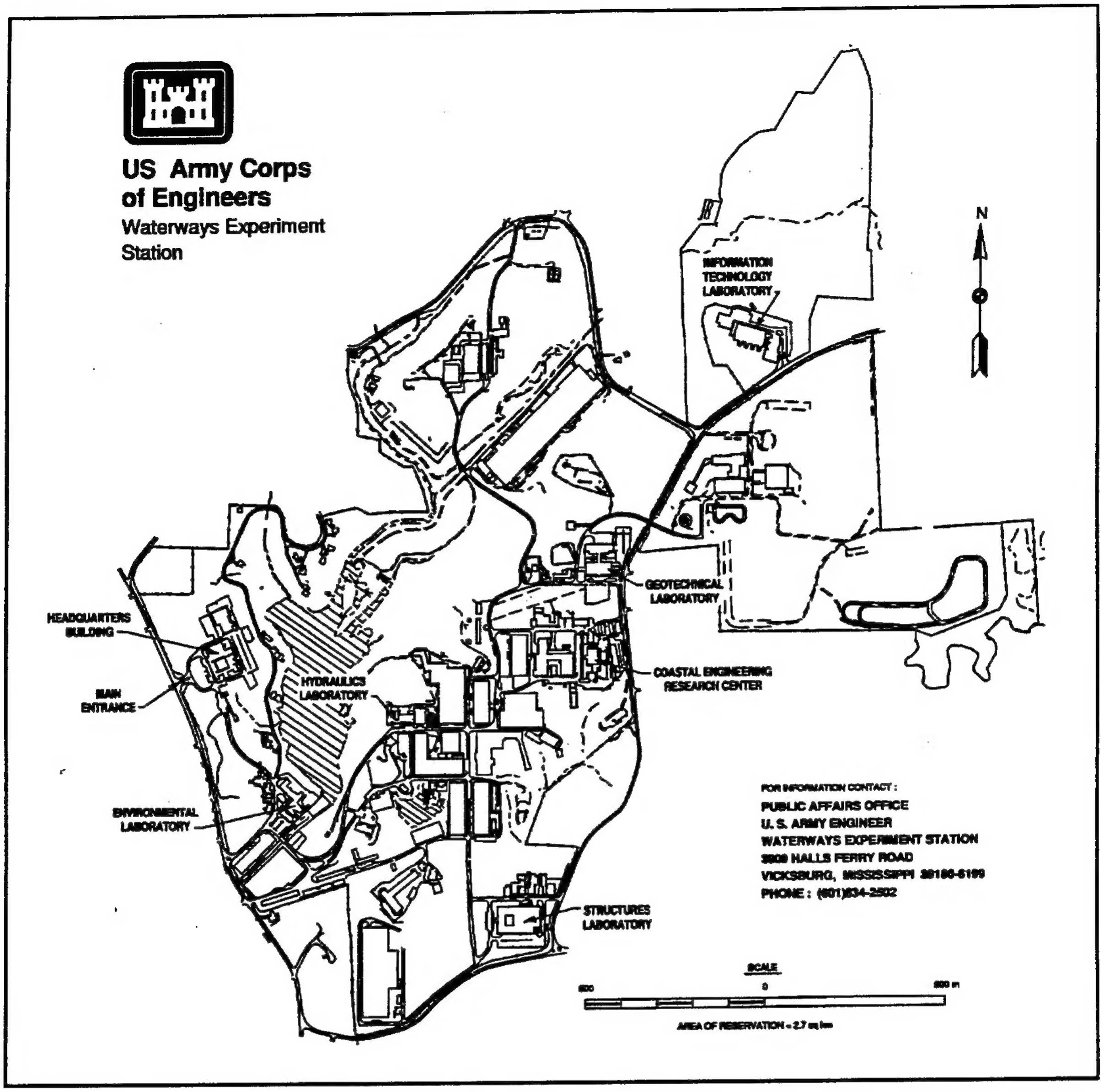

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Contents

Preface

The movable-bed model investigation reported herein was conducted for the U.S. Army Engineer District, Memphis (LMM), in the Hydraulics Laboratory (HL), U.S. Army Engineer Waterways Experiment Station (WES), Vicksburg, MS, during the period from March 1987 to June 1995. The investigation was conducted under the general supervision of Messrs. F. A. Herrmann, Jr., former Director, HL; R. A. Sager, Acting Director, HL; and R. F. Athow, Acting Assistant Director, HL, under the direct supervision of Messrs. J. E. Glover and M. B. Boyd, former Chiefs of the Waterways Division, HL. The engineer in immediate charge of the investigation was Mr. T. J. Pokrefke, Chief, River Engineering Branch, Waterways Division. Mr. Pokrefke was assisted by Messrs. C. R. Nickles, R. H. Emerson, and C. Shields, Waterways Division. This report was prepared by Mr. Nickles.

During the course of the model study, LMM was kept informed of the progress of the study through monthly progress reports and interim model results. Messrs. B. J. Littlejohn, D. G. Jackson, and E. E. Belk, LMM, visited WES to observe model operation, discuss model results, and coordinate the study program. These visits were also attended by Messrs. J. R. Tuttle, Max Lamb, and C. M. Elliot of the U.S. Army Engineer Division, Lower Mississippi Valley. In August 1988, the Honorable Richard Hackett, Mayor, City of Memphis, and six city officials visited WES to view the model and were briefed on the model results.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Bruce K. Howard, EN.

1 Introduction

Description of Problem

The Loosahatchie-Memphis reach is the portion of the lower Mississippi River that lies adjacent to Memphis, TN (Figure 1). This reach lies within the U.S. Army Engineer District, Memphis. The reach includes the entrance to the Memphis Harbor, the confluence with the Wolf and Loosahatchie Rivers, and Mud Island and is crossed by four bridges. Three of the bridges, two railway and U.S. Highway 61, cross about 1.6 km (1 mile) downstream of the entrance to the harbor, and the Interstate 40 (I-40) Highway bridge crosses about 1.6 km (1 mile) upstream of the harbor.

The problem in this reach of river is twofold. Over recent history the low-water rating curve at Memphis has been decreasing, and shoaling upstream of the I-40 Highway bridge has increased, which has resulted in increased dredging requirements to maintain a channel through the I-40 bridge during low-water periods. The channel alignment in the bridge approach has been unstable and has meandered from one side of the river to the other.

The other problem associated with this reach has been the instability of the left riverbank immediately downstream of the entrance to the harbor. The bank line, although revetted, is geologically active, causing extensive damage to Riverside Drive, which runs along the top of the bank. Studies of the area by the Memphis District have shown that an overburden of sand on the toe of the bank line revetment is alternately deposited then removed by the river. The results of the study showed that the instability of the bank line is directly proportional to the amount of overburden on the toe. The U.S. Army Corps of Engineers Master Plan for dike construction in this reach includes the addition of some dikes directly across the river from the unstable bank. If the construction of these dikes causes the overburden to be removed and not redeposited or causes scour at the toe of the revetment, the bank line could fail.

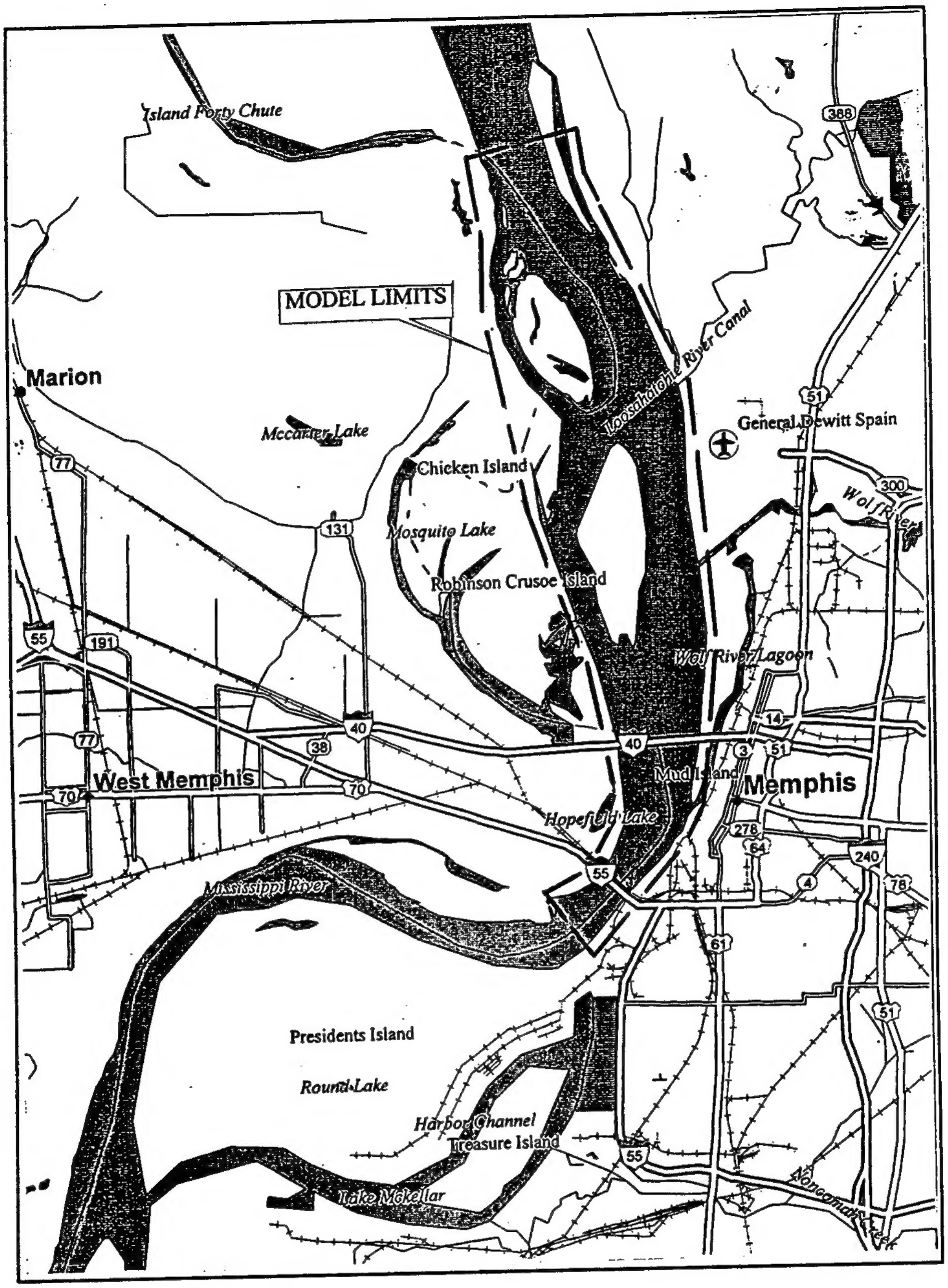

Figure 1. Location map

Purpose of the Model Study

The purpose of the Loosahatchie-Memphis reach movable-bed model study was to evaluate the effects of the Master Plan on the stability of the left bank downstream of the entrance to Memphis Harbor and to evaluate improvement schemes that will maintain a navigation channel of sufficient depth during

low-water periods and reduce dredging requirements in the upstream approach to the I-40 highway bridge. The City of Memphis had proposed a plan to construct a berm along the left bank in an effort to stabilize the bank and reduce the damage to Riverside Drive. Another purpose of this study was to evaluate the effect of the berm construction on the overall development of the modeled reach.

2 The Model

Description

The movable-bed model used for this study reproduced to a horizontal scale of 1:300 and a vertical scale of 1:100 the reach of the Mississippi River between miles 738.8 and 743.5[1] including the overbank areas between the main-line levees. The model was extended upstream during the course of the study to mile 745.0. The scales selected resulted in a model scale distortion of 3, which is acceptable for a model of this type. This area reproduced the mouths of the Loosahatchie and Wolf Rivers, but because of the inconsistent discharge patterns of these tributaries, it was determined that their discharges would not impact the main channel development. Therefore, no provisions were provided for discharges from these two rivers in the model. The model also included approximately 1.6 km (1 mile) of the lower end of the Memphis Harbor channel and Mud Island. The model was constructed with the banks fixed above el +10.0[2] and the overbank areas molded in sand-cement mortar. The steep portions of the banks below el +10.0 and all dikes were molded using 19-mm (3/4-in.) crushed stone. The remaining river channel was molded in crushed coal having a median diameter of 2 mm and a specific gravity of 1.30.

Overbank portions of the model were molded in accordance with data shown on U.S. Geological Survey maps, and the river portion was molded to a January 1986 prototype hydrographic survey (Plate 1).

Appurtenances

Water was supplied to the model by a 0.28-cu m/sec (10-cfs) axial flow pump operating in a recirculating system and was measured with 30.5- by 15.2-cm (12- by 6-in.) and 15.2 by 7.6-cm (6- by 3-in.) venturi meters. Water-surface elevations in the model were controlled by a slide-type tailgate

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[1] River miles above Head of Passes.

[2] All elevations (el) and stages cited herein are in feet referred to the 1974 Low-Water Reference Plane (LWRP). To convert them to meters, multiply by 0.3048.

at the downstream end of the model and were measured by piezometers located approximately 1.61 km (1 mile) apart in the channel. A graduated container was used to measure the material introduced at the upstream end of the model. A sediment trap was provided at the downstream end of the channel where sediment discharged from the model could accumulate and be measured when desired. A carefully graded rail was installed along each side of the channel to support sheet metal templates used for molding the movable-bed portion of the model prior to some experiments. These rails were also used to provide vertical control for surveying the model bed.

Verification

Before improvement plans were run in the model, adjustments were made until the model reproduced, to a reasonable degree of accuracy, changes that had occurred in the prototype. This process is referred to as model verification. The verification process establishes the discharge scales, rate of introducing bed material for each flow reproduced, supplemental slope required to produce movement of the bed material, model operating technique, and accuracy to which the model reproduces prototype conditions.

Verification of the model was started with the channel molded to the conditions of the January 1986 prototype survey. The model was then operated by reproducing the flow hydrograph that occurred in the river during the period 15 January 1986 through 30 November 1986 (Plate 2 and Table 1). The operation was repeated and adjustments were made until the model reproduced with reasonable accuracy the essential characteristics of the reach and channel configuration indicated by the November 1986 prototype survey (Plate 3).

Results of the final adjustment run shown in Plate 4 indicate that the model reproduced the general characteristics of the prototype reach, and the verification was considered adequate for the purpose of the study. Comparison of the results of the model verification with the prototype survey of November 1986 (Plate 3) indicates the model reproduced the general shape of the channel throughout the modeled reach. The degradation of the bed along the right side of the channel near the Redman Point Bar Dikes was somewhat deeper in the prototype survey than in the model, and aggradation across the entire channel width downstream of the Redman Point Bar dikes (mile 739.5 to 741.0) was greater. The left side of the channel between mile 740.0 and the I-40 Highway bridge was generally reproduced in the model, but the right side of the channel at the ends of the Loosahatchie Bar dikes to the I-40 Highway bridge was somewhat deeper in the prototype than reproduced in the model. The model bed was generally deeper than the prototype from the I-40 Highway bridge to the end of the model (mile 743.5). These differences and tendencies have to be considered in the evaluation of the results of the experiments with

improvement plans. For a detailed description of the verification process, see Franco[1].

Operation and Results

Operation procedure

After verification of the model, the model was operated to determine channel development with one or more reproductions of a typical annual hydrograph and to provide a basis for comparing the effects of various improvement plans. The typical annual hydrograph used during the model operation to evaluate most plans was developed from a typical stage hydrograph used for a model study of Buck Island Reach[2], located upstream of the Loosahatchie-Memphis reach (Plate 5 and Table 2). The corresponding discharge for each stage was obtained from a stage-discharge rating curve for the years 1973, 1985, and 1986 at the Memphis gaging station. Various plans were also subjected to one or more reproductions of a blocked representation of the Mississippi River flood hydrograph of 1973 at the Memphis gaging station (Plate 6 and Table 3) to determine the effect of flood flows on channel stability. Each reproduction of the typical annual or 1973 flood hydrographs is herein referred to as a "run." Normally operation to evaluate improvement plans or modifications was started with the bed configuration of the model in the same condition as that obtained at the end of the preceding model evaluation. Other evaluations were started with the bed molded to a specified prototype survey. For shallow-draft channels, a channel 3 m (10 ft) below the LWRP is considered adequate, but because of the extremely low water stages experienced at Memphis during the past several years, a channel 6 m (20 ft) below the LWRP will be considered adequate for this study. The bed of the model was surveyed and mapped at the end of each run. Also, the bed material discharged from the model was removed and measured at the end of each run. Only final results or significant changes produced by each plan or modification are included in this report.

Base conditions

Description. The model was operated using base conditions to obtain an indication of development of the model bed for a "do-nothing" condition for flows of the typical annual hydrograph. For these base conditions, all changes indicated in the model were a direct result of the hydrograph used. Model

[1] J. J. Franco. (1978). "Guidelines for the design, adjustment and operation of models for the study of river sedimentation problems," Instruction Report H-78-1 (including Appendixes A-C), U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
[2] C. R. Nickles. (1985). "Buck Island Reach, Mississippi River; hydraulic model investigation," Technical Report HL-85-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

operation was initiated for base conditions with the bed of the model molded to the conditions indicated by the January 1986 prototype survey (Plate 1). The hydrograph was repeated until the model reached stability, a condition for which the bed material input and output were approximately equal and no significant changes in the model bed form occurred from run to run. The typical annual hydrograph was repeated 13 times, then the model was subjected to one run of the 1973 flood hydrograph. The results of these base conditions were the basis of comparison of all improvement plans and modifications.

Results. Results of the model operation for base conditions after 13 runs is shown in Plate 7. The results indicated the entire channel upstream of the Hopefield Point dike shoaled and the el -20 channel was not present in several locations. The channel from the Hopefield Point dike downstream to the three bridge crossings was somewhat deeper along the left bank. Large deposits occurred in the channel between miles 742.0 and 743.0, 739.5 and 741.5, and 736.0 and 737.5. The thalweg near the ends of the Above Loosahatchie dikes 5 and 6 was shifted away from the ends of the dikes toward the middle of the channel. The tendency of the prototype channel between miles 740.0 and 743.5 to meander was also indicated in the model. Also, the model indicated, as in the prototype, a tendency to shoal upstream of the I-40 Highway bridge with no definite channel being developed.

It should be kept in mind that the developments and results of these conditions were the result of the typical annual hydrograph with very few bank-full or above flows. Other hydrographs would produce different results, but since one of the purposes of the study was to reduce the shoaling in the channel above the I-40 Highway bridge, these results were considered adequate as a basis of comparison for improvement plans or modifications.

The results of the base conditions with the typical annual hydrograph (Plate 7) was subjected to one run of the 1973 flood hydrograph. The results, shown in Plate 8, indicate the channel alignment remained about the same with some additional shoaling occurring about mile 743.0. Some deepening of the channel near the I-40 Highway bridge occurred, but an el -20 channel did not exist.

Master Plan

Description. The Master Plan was supplied by the Memphis District as part of the comprehensive dike plan for the lower Mississippi River. For the modeled reach the Master Plan consisted of four additional dikes upstream of the Loosahatchie Bar dikes and four dikes, two upstream and two downstream of the Hopefield Point dike. An additional purpose of studying this plan was to determine the effects of the additional Hopefield Point dikes on the stability of the left riverbank immediately downstream of the entrance to the Memphis Harbor and their impact on the proposed berm to be placed in that area by the City of Memphis to stabilize Riverside Drive. Before the Master Plan was

installed in the model, the bed was remolded to the January 1986 prototype survey.

The four dikes added to the Loosahatchie Bar dikes were designated dikes 1U through 4U and were constructed at miles 739.9, 740.3, 740.6, and 741.0, respectively. Hopefield Point dikes 1U and 2U were added upstream of the existing dike at miles 736.5 and 736.8 and dikes 2 and 3 were added downstream at miles 735.7 and 735.4. The dikes added are as follows:

a. Loosahatchie Bar dike 1U was 236.2 m (775 ft) in length at az 266° 38′ with the bank end at el +20, then sloped for 83.8 m (275 ft) to el +15, then sloped for 152.4 m (500 ft) to el +5.

b. Loosahatchie Bar dike 2U was 466.3 m (1,530 ft) in length at az 249° 26′ with the bank end at el +20, then sloped for 121.9 m (400 ft) to el +15 and extended for 192.0 m (630 ft) at el +15, then sloped for 152.4 m (500 ft) to el +5.

c. Loosahatchie Bar dike 3U was 378.0 m (1,240 ft) in length at az 279° 18′, then extended another 460.2 m (1,510 ft) at az 255° 07′. The total length of dike 3U was 838.2 m (2,750 ft) with bank end at el +20, then sloped for 121.9 m (400 ft) to el +15 and extended for 563.9 m (1,850 ft) at el +15, then sloped for 152.4 m (500 ft) to el +5.

d. Loosahatchie Bar dike 4U was 477.0 m (1,565 ft) in length at az 249° 16′, with the bank end at el +20, then sloped for 121.9 m (400 ft) to el +15 and extended for 202.7 m (665 ft) at el +15, then sloped for 152.4 m (500 ft) to el +5.

e. Hopefield Point dike 1U was 387.1 m (1,270 ft) in length at az 275° 32′ with the bank end at el +20, then sloping for 121.9 m (400 ft) to el +15 and extending for 112.8 m (370 ft) at el +15, then sloped for 152.4 m (500 ft) to el +5.

f. Hopefield Point dike 2U was 236.2 m (775 ft) long at az 245° 37′, then extended another 358.1 m (1,175 ft) at az 280° 11′ for a total length of 594.4 m (1,950 ft). The bank was at el +20, then sloped for 121.9 m (400 ft) to el +15 and extended for 320.0 m (1,050 ft) at el +15, then sloped for 152.4 m (500 ft) to el +5.

g. Hopefield Point dike 2 was 403.9 m (1,325 ft) in length at az 288° 51′ with the bank end at el +20, then sloped for 121.9 m (400 ft) to el +15 and extended for 129.5 m (425 ft) at el +15, then sloped for 152.4 m (500 ft) to el +5.

h. Hopefield Point dike 3 was 221.0 m (725 ft) in length at az 302° 00′ with the bank end at el +20, then sloped for 68.6 m (225 ft) to el +15, then sloped for 152.4 m (500 ft) to el +5.

Results. The results of the model operation after 11 runs of the typical annual hydrograph with the Master Plan dike scheme in place are shown in Plate 9. The results indicated the channel would be slightly improved compared with the channel developed during the base conditions. An el -20 channel was maintained from mile 740.0 to 743.5, but the alignment of the channel was poor. As in the base conditions, the channel near the I-40 Highway bridge shoaled, but the shoal was smaller and deeper; however, the shoal would significantly impact navigation at low river stages. Based on these results, the addition of the Master Plan dikes would not significantly improve the navigation channel through the modeled reach.

A plot of the riverbed elevation at the toe of the bank in the area of the proposed stability berm (miles 734.9 to 735.8) is presented in Plate 10. Compared with the base condition runs, the results indicated the elevation at the toe for the downstream half of the proposed berm site was about the same; but with the Master Plan dikes in place, the elevation at the toe for the upstream half of the site was much lower. The increase in depth at the toe could significantly decrease the stability or cause failure of the left riverbank between river miles 734.9 and 735.8.

Stability berm plan

Description. The modeling of the stability berm plan was conducted to determine if the berm would have any effect on the riverbed formation. Before the stability berm was installed in the model, the proposed Master Plan dikes were removed and the model remolded to the conditions of the January 1986 prototype survey. The berm began on the left bank at the entrance to Memphis Harbor (mile 735.9) and extended downstream along the left bank to about mile 734.9. The berm was constructed to a top elevation of +51, thus realigning the shape of the bank line. The condition of the model at the beginning of this operation is shown in Plate 11.

Results. The model results with the stability berm in place after seven runs are shown in Plate 12. A comparison of the final base conditions run (Plate 7) with these results indicated the berm had no effect on the channel development except just upstream of the berm. The shoaling in the main river channel between miles 736.0 and 737.5 that occurred during the base conditions did not occur with the berm in place. An el -20 channel of a minimum width of about 121.9 m (400 ft) was maintained through the I-40 Highway bridge and past the berm. Although the lower half of the model channel (miles 739.0 to 738.8) was improved and maintained an el -20 channel throughout, the upper half (miles 743.5 to 339.0), as in the base conditions, was too shallow and poorly aligned for a satisfactory navigation channel.

3 The Extended Model

Description

In order to study the channel development in the upper half of the model, the model was extended an additional 2.4 km (1.5 miles) upstream to river mile 745.0. The extension of the model allowed a more detailed and accurate reproduction of the river crossing between river miles 741.0 and 743.0 by moving the model entrance further upstream, thus reducing the effects of the entrance conditions on the crossing development. The extension was constructed as previously described. Since the entrance conditions at the beginning of the model are critical and developed during the model verification, a new verification was required to adjust the entrance conditions. All model operations hereafter were performed on the extended model.

Verification

The extended model verification, like the original model verification, was started with the channel molded to the conditions of the January 1986 prototype survey (Plate 13), except the stability berm was included in the model. As with the original verification, the model was operated using the January through November 1986 hydrograph (Plate 2), and operations were repeated with adjustments made only to the entrance conditions until the model reproduced the essential characteristics of the November 1986 prototype survey (Plate 14). Since the discharge ratio, supplemental slope, and bed material feed rate were determined during the initial verification and are not significantly affected by the model entrance, they were unchanged and not modified during the verification of the extended model.

The results of the extended model verification, shown in Plate 15, indicated the model reproduced with good accuracy the general characteristics of the bed configuration of the November 1986 prototype survey (Plate 14).

Operation and Results

Base conditions

Description. After the verification of the extended model, a base condition was conducted for flows of the typical annual hydrograph (Plate 5) to obtain results using the extended model for comparing the merits of improvement plans. Before the model was operated for the extended model base conditions, it was remolded to the bed configuration of the January 1986 prototype survey (Plate 13).

Results. The model results after 16 runs of the typical annual hydrograph are shown in Plate 16. The results indicated the channel between river mile 740.0 and 745.0 was poorly aligned, and a low-water channel (el -20) did not exist at mile 743.6 or 741.0. The minimum width of the low-water channel in the upstream approach of the I-40 Highway bridge (miles 736.6 to 738.0) was about 274.3 m (900 ft). The minimum width of the low-water channel downstream of the I-40 Highway bridge was about 106.7 m (350 ft), with the minimum width occurring near the upstream end of the stability berm.

Plan A

Description. Plan A was designed to improve the crossing between river miles 745.0 and 743.0 by decreasing the low-water channel controlling width to approximately 609.6 m (2,000 ft). Before Plan A was installed, the model was remolded to the bed configuration of the January 1986 prototype survey. Plan A consisted of the following:

a. Above Loosahatchie Dike No. 1 was extended riverward approximately 109.7 m (360 ft) at crest el +15. The extension was angled upstream about 0.26 rad (15 deg) from the existing alignment.

b. Above Loosahatchie Dike No. 2 was extended along the existing alignment of the dike riverward about 213.4 m (700 ft) and extended about 335.3 m (1,100 ft) to tie into the riverbank. The total length of the dike was approximately 762.0 m (2,500 ft) at crest el of +16.

c. Above Loosahatchie Dike No. 3 was extended along the existing alignment approximately 152.4 m (500 ft). The total length of the dike was about 716.3 m (2,350 ft) at crest el +16.

d. Above Loosahatchie Dike No. 1U was added approximately 914.4 m (3,000 ft) upstream of Dike No. 1. Dike No. 1U extended from the bank at about az 272° for 320.0 m (1,050 ft) then extended an additional 600.5 m (1,970 ft) at approximate az 253°. The crest elevation was +15.

e. Each of these dikes were constructed with the last 152.4 m (500 ft) of the stream end of the dike being sloped from the crest elevation to el +5. The bank ends of the dikes were sloped for 76.2 m (250 ft) from the crest elevation to tie to the top bank.

Results. The results after two repetitions of the typical hydrograph are shown in Plate 17. The results indicated a low-water (el -20) channel would exist between miles 743.0 and 745.0, but as with the base conditions the alignment was unsatisfactory. The minimum width of the low-water channel in the upstream approach to the I-40 Highway bridge was approximately 137.2 m (450 ft) and downstream of the bridge the minimum width was about 213.4 m (700 ft). Due to the poor development of the channel between miles 740.0 and 745.0, operation of the model for Plan A was discontinued.

Plan B

Description. Plan B consisted of adding a 30.5-m (100-ft) L-head to the Above Loosahatchie Dikes 1U and 1 at el +15. The L-heads were angled riverward 0.26 rad (15 deg) from a line connecting the stream ends of the dikes in the dike field. Plan B reduced the low-water channel controlling width between the Above Loosahatchie Dikes 1U, 1, and 2, and the Redman Point dikes to about 579.1 m (1,900 ft). Plan B was installed in the bed configuration obtained after the second run of Plan A. Three repetitions of the typical hydrograph were run with Plan B.

Results. The results after the third run of Plan B are shown in Plate 18. The results indicate that a low-water channel (el -20) between miles 743.0 and 745.0 was somewhat wider than with the base conditions and Plan A, but as with the previous plans the channel alignment was unsatisfactory because of the two short thalweg crossings between miles 742.0 and 744.0. Shoaling in the upstream approach to the I-40 Highway bridge decreased the minimum width of the low-water channel to approximately 45.7 m (150 ft). Shoaling along the left side of the channel downstream of the bridge reduced the minimum width to about 152.4 m (500 ft) near the upstream end of the stability berm. Because of the poor development of the channel between miles 743.0 and 745.0, operation of the model for Plan B was suspended.

Plan C

Description. Plan C was the same as Plan B except for the following modifications:

a. Above Loosahatchie Dike No. 3 was extended riverward an additional 45.7 m (150 ft) for a total length of 198.1 m (650 ft)) at el +16.

b. Above Loosahatchie Dike No. 4 was extended riverward approximately 182.9 m (600 ft) at el +15.

c. Above Loosahatchie Dike No. 5 was extended riverward approximately 121.9 m (400 ft) at el +15.

d. Redman Point Dike No. 1-1/2, a pile dike, was filled with stone at crest el +16.

Plan C was designed to extend the 579.1-m (1,900-ft) channel control width initiated in Plan B downstream through the river reach between the Above Loosahatchie Dike field and Redman Point Bar (mile 741.08). Plan C was installed in the bed configuration obtained at the end of Plan B. Two repetitions of the typical hydrograph were run with Plan C.

Results. The results after two runs are shown in Plate 19. The results indicate the channel width and alignment were about the same as with Plan B. The low-water channel between miles 743.0 and 745.0 was somewhat improved over the previous plans but continued to be poorly aligned. Shoaling in the upstream approach to the I-40 Highway bridge caused the el -20 channel to be disconnected through the bridge. Shoaling along the left side of the channel near the upstream end of the stability berm continued to increase in elevation, but did not significantly affect the low-water channel width obtained with Plan B. Because of the poor channel development between miles 743.0 and 745.0, and the loss of the low-water channel through the upstream approach to the I-40 Highway bridge, no further model runs were made with Plan C.

Base conditions, April 1990 prototype survey

Description. After completion of the previous model operation, the Memphis District provided a recent prototype survey taken in April 1990 (Plate 20). Unlike the January and November 1986 prototype surveys previously used in the model, the April 1990 survey was taken after construction of the stability berm. The April 1990 survey reflected the same general features and tendencies as the January and November 1986 surveys (Plates 13 and 14), except for a large deposit in the main channel from about mile 740.6 to 741.5. Both the base condition results with the original and extended models (Plates 7 and 16) indicate the tendency to shoal in the same area. In an effort to have the model results reflect the most current conditions of the prototype and because of the similarity of the April 1990 survey to previous model results, the April 1990 prototype survey was used from here on as the initial bed configuration for improvement plans. The April 1990 prototype survey was molded into the model, then subjected to 11 repetitions of the typical annual hydrograph to reach stability to obtain base conditions for comparison to improvement plans.

Results. The results after the eleventh run are shown in Plate 21. The results indicated a channel of good depth, width, and alignment was developed from mile 745.0 downstream to mile 742.0. The shoal in the channel, indicated by the prototype survey, between miles 741.0 and 742.0 was not

removed. Shoaling from mile 738.0 downstream to the I-40 Highway bridge essentially closed the low-water navigation channel, and the channel was narrow near the upstream end of the stability berm.

Plan D

Description. Plan D was provided by the Memphis District. Plan D consisted of modifications to five of the Above Loosahatchie dikes, the addition of four dikes on the right side of the river between Redman Point and Loosahatchie Bars, and the addition of two dikes upstream and two dikes downstream of the existing Hopefield Point dike. The dikes added between Redman Point Bar and Loosahatchie Bar were designated Sycamore Chute Dikes 1 through 4. The dikes added upstream of the Hopefield Point dike were designated Hopefield Point Dikes 1U and 2U. The dikes added downstream of the Hopefield Point dike were designated Hopefield Point Dikes 2 and 3. The Plan D features are as follows:

a. Above Loosahatchie Dike No. 1 was extended approximately 304.8 m (1,000 ft) to tie to the bank. The extension was angled about 0.24 rad (14 deg) downstream of the dike's existing alignment. The dike was also extended about 173.7 m (570 ft) riverward at an angle of about 0.26 rad (16 deg) upstream of the existing alignment. The dike crest was at el +15 except for the riverward end, which was sloped for 91.4 m (300 ft) down to el 0.

b. Above Loosahatchie Dike No. 2 was extended toward the bank about 137.2 m (450 ft) along the existing alignment, then angled 0.09 rad (5 deg) downstream of the existing alignment for an additional 291.1 m (955 ft) for a total length of 428.2 m (1,405 ft) to tie into the bank. The stream end of the dike was extended approximately 213.4 m (700 ft) and was angled about 0.10 rad (6 deg) upstream of the existing alignment. The dike crest elevation was +15 except for the stream end, which was sloped for 91.4 m (300 ft) down to el 0.

c. Above Loosahatchie Dikes 3, 4, and 5 were extended riverward approximately 160.0, 91.4, and 30.5 m (525, 300, and 100 ft), respectively, along their existing alignments. The crest elevation for Dike 3 was +15, and +12 for Dikes 4 and 5. All three dikes were sloped at the stream end for 91.4 m (300 ft) from their crest elevations down to el 0.

d. Four Sycamore Chute dikes were added on the right side of the river channel between river miles 739.9 and 741.3. Dike No. 1 began near the downstream end of Redman Point Bar at mile 741.3 and extended about 157.0 m (515 ft) at az 260° 28′ at crest el +15, then extended approximately another 207.3 m (680 ft) at az 240° 32′ and sloped from crest el +15 to +10 at the stream end. Dike No. 2 also began near the downstream end of Redman Point Bar at mile 740.8 and extended approximately 309.4 m (1,015 ft) at az 279° 28′ at crest el +15, then

extended an additional 173.7 m (570 ft) at az 245° 02′ at el +15, then extended another 243.8 (800 ft) along the same azimuth sloping downward to crest el +10 at the stream end. Dike No. 3 began near the upstream end of Loosahatchie Bar at mile 740.2 and extended at az 212° 33′ for about 307.8 (1,010 ft) at crest el +15, then sloped for about 182.9 m (600 ft) to el +10 at the stream end along az 254° 18′. Dike No. 4 also began near the upstream end of Loosahatchie Bar at mile 739.9 and extended at az 244° 09′ for about 103.6 m (340 ft) at crest el +15, then sloped for about 146.3 m (480 ft) to el +10 at the stream end along az 255° 43′.

e. Hopefield Point Dikes 1U and 2U were constructed on the right side of the river between Robinson Crusoe Dike No. 6 and Hopefield Point Dike No. 1. Dike 1U began on the right bank at mile 736.8 and extended for about 219.5 m (720 ft) along az 235° 08′, then for an additional 487.7 m (1,600 ft) along az 270° 15′. The crest elevation was +10 except for the riverward end, which sloped for 121.9 m (400 ft) from el +10 to el 0. Dike 1U was approximately 609.6 m (2,000 ft) downstream of Robinson Crusoe Dike No. 6. Dike 2U was located approximately 579.1 m (1,900 ft) upstream of Hopefield Point Dike No. 1, and began on the right bank at mile 736.5 at crest el +10, then extended riverward for about 481.6 m (1,580 ft) along az 274° 35′ to el 0.

f. Hopefield Point Dikes 2 and 3 were located downstream of the existing Hopefield Point dike approximately 573.0 and 1,188.7 m (1,880 and 3,900 ft), respectively. Dike No. 3 was about 0.80 km (0.5 mile) upstream of the Harahan Bridge. Dike No. 2 began at the right bank at mile 735.7 and extended riverward along az 281° 33′ for approximately 163.1 m (535 ft) then extended another 243.8 m (800 ft) along az 292° 32′. The crest elevation of Dike 2 was +10 at the bankhead then sloped to el 0 at the river end. Dike No. 3 began on the right bank at mile 735.3 at el +10 then extended riverward along az 302° 42′ for 263.7 m (865 ft) to el 0.

Before operation of the model to evaluate Plan D, the model was remolded to the April 1990 prototype conditions. The initial conditions for Plan D are shown in Plate 22.

Results. The results after seven runs of the typical annual hydrograph are shown in Plate 23. The results indicated a navigation channel would develop along the ends of the Redman Point Dikes and align along the right bank through mile 742.0, then cross the main channel to the left bank at mile 740.0. This provided a good alignment with a minimum width of the low-water channel of 198.1 m (650 ft). The channel remained along the left bank from mile 740.0 through the rest of the modeled reach. The minimum low-water channel width approaching the I-40 Highway bridge was 106.7 m (350 ft). In general this plan provided a low-water channel of satisfactory width and alignment.

Plan E

Description. Plan E was provided by the Memphis District and was based on dikes that had been constructed or were scheduled for construction in the prototype in the near future. Before Plan E was installed in the model, all of the dike modifications for Plan D were removed. Plan E consisted of the following:

a. The Above Loosahatchie Dike No. 1 was extended to the bank. The extension was angled about 0.24 rad (14 deg) downstream of the existing dike alignment. This provided an alignment that was normal to the flow in the channel between the dike and the bank line. The elevation of the dike crest was raised to +15 except for a 45.7-m- (150-ft-) wide notch at el 0 in the back channel.

b. The Above Loosahatchie Dike No. 2 was also extended to the bank line. The extension began at the groundline at the bank end of the dike and extended on an angle of about 0.17 rad (10 deg) downstream of the existing alignment to tie into the bank. The existing dike and extension were at crest el +15 except for a 79.2-m- (260-ft-) wide notch at el 0 in the back channel.

c. Four Sycamore Chute dikes were added on the right side of the river between miles 740.1 and 741.3. Dike No. 1 began on the lower end of Redman Point Bar at mile 741.3 at el +20, sloped for 201.2 m (660 ft) at az 266° 39′ to el +5, then extended at el +5 for 121.9 m (400 ft) at az 238° 30′. Dike No. 2 began on Redman Point Bar at mile 740.9 and ran along az 270° 04′ for 283.5 m (930 ft), then along az 244° 00′ for 304.8 m (1,000 ft). Dike No. 2 began at the bank at el +20, then sloped for 213.4 m (700 ft) to el +15, then sloped for 167.6 m (550 ft) to el +5, then remained level to the stream end. Dikes 3 and 4 began on the upstream end of Loosahatchie Bar. Dike No. 3 began at mile 740.3 at el +18, then sloped for 403.9 m (1,325 ft) along az 201° 28′ to el +10, then extended at el +10 for 198.1 m (650 ft) along az 238° 38′. Dike No. 4 began at mile 740.1 at el +15, then sloped for 182.9 m (600 ft) along az 239° 00′ to el +10, then extended another 167.6 m (550 ft) along az 247° 00′ at el +10.

Before operation of the model to evaluate Plan E was undertaken, the model was remolded to the April 1990 prototype bed configuration.

Results. The model results after 11 repetitions of the typical annual hydrograph are shown in Plate 24. The results indicated the channel would shift from the ends of the Above Loosahatchie dikes to the right side of the river and remain along the ends of the Redman Point and the Redman Point Bar dike fields. This produced a good channel alignment throughout the model. Although an el -20 channel was not continuous throughout the model, if the model had been run to stability, indications are that the el -20 channel would have continued to develop. The model was not operated to stability, because

the Memphis District provided a modification scheduled for construction in the prototype to be added to the plan installed into the model. This plan provided a good upstream approach to the I-40 Highway bridge.

Plan F

Description. Plan F was the same as Plan E with the addition of a curved longitudinal dike along the right side of the river connecting the Redman Point and Redman Point Bar dike fields. The longitudinal dike was constructed at crest el +25 and ran from about mile 743.7 to mile 742.0 with a radius of 11,155.7 m (36,600 ft). The total length of the longitudinal dike was approximately 2,621.3 m (8,600 ft). Also included in Plan F was the raising of the crest of Robinson Crusoe Dike No. 1 to el +20 across its entire length. The model was remolded to the April 1990 prototype bed configuration. The Plan F dikes and initial bed configuration are shown in Plate 25.

Results. After six runs of the typical annual hydrograph, the model operation to evaluate Plan F was terminated to install two additional dikes at Hopefield Point. The model results after the sixth run are shown in Plate 26. The results indicated the bar along the face of the longitudinal dike was removed and the channel shifted to the face of the dike. The shifting of the channel, as in Plan E, produced a good channel alignment throughout the model and indicated an el -20 channel would continue to develop if run to stability.

Plan F-Modified

Description. Plan F-Modified was the same as Plan F except for two dikes added on the right side of the river between the Robinson Crusoe Dike No. 6 and the Hopefield Point dike. The dikes were designated Hopefield Point Dikes 1U and 2U. The crest elevations of Sycamore Chute Dikes 1, 2, and 4 were modified and both alignment and crest elevation were modified for Sycamore Chute Dike No. 3. This is the final design for construction by the Memphis District. The modification features were as follows:

a. The origin on the bank and alignment of Sycamore Chute Dikes 1 and 2 were not changed from Plan F. The crest of Dike No. 1 was changed to originate at el +20, then slope for about 131.1 (430 ft) to el +10, then was level crested to its stream end. Dike No. 2 began at el +18 at the bank and sloped for 283.5 m (930 ft) to el +10 at the change in alignment, then was level crested to its stream end.

b. The alignment and crest elevation of Sycamore Chute Dike No. 3 were modified from Plan F. The dike began at el +15 at the same point on Loosahatchie Bar as in Plan F, but then sloped for 76.2 m (250 ft) to el +13 and extended another 222.5 m (730 ft) along az 172° 00′ at

el +13, then sloped downward for 21.3 m (70 ft) to el +5 along az 242° 00′ and extended an additional 381.0 m (1,250 ft) at el +5.

c. The alignment of Sycamore Chute Dike No. 4 was not changed from Plan F, but the crest elevation was changed to el +12 at the bank then sloped for 82.3 m (270 ft) to el 0 and was level at el 0 to the stream end of the dike.

d. Hopefield Point Dike No. 1U began at el +10 on the right bank at mile 736.5 and extended along az 274° 00′ for 76.2 m (250 ft) to el +5 and continued level at el +5 for an additional 350.5 m (1,150 ft). A 15.2-m- (50-ft-) wide notch was provided in the dike at el +5 about 152.4 m (500 ft) from the bankhead.

e. Hopefield Point Dike No. 2U began at el +12 on the right bank at mile 736.8, then ran level along az 233° 00′ for 259.1 m (850 ft), then along az 271° 00′ for another 182.9 m (600 ft), then sloped downward along the same alignment for 274.3 m (900 ft) to el -3 at the stream end.

Plan F-Modified was installed in the bed configuration obtained at the end of Plan F run 6 (Plate 26).

Results. The results after seven runs of the typical annual hydrograph are shown in Plate 27. The results indicated the el -20 channel would continue to develop along the face of the longitudinal dike, then cross the river to align along the left bank revetment on Mud Island. The alignment was good and of sufficient width except in the approach to the I-40 Highway bridge. Shoaling in the upstream approach to the bridge decreased channel depth and reduced the channel width to a minimum of about 61.0 m (200 ft). Based on the Plan F-Modified results, a satisfactory low-water navigation channel can be maintained with the proposed structures. The tendency for shoaling to occur in the upstream approach to the I-40 Highway bridge could result in the loss of navigation depth at low stages for some river hydrographs.

Plan G

Description. Plan G was a series of bendway weirs between miles 744.0 and 745.1 designed to address the tendency to shoal in the upstream approach of the I-40 Highway bridge, which could result in the loss of the low-water channel for some hydrographs. The bendway weir concept had been developed on a movable-bed model study of the Mississippi River conducted by the U.S. Army Engineer Waterways Experiment Station for the U.S. Army Engineer District, St. Louis.[1] The results of those experiments indicated that

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[1] David L. Derrick, Thomas J. Pokrefke, Jr., Marden B. Boyd, James P. Crutchfield, Raymond R. Henderson. (1994). "Design and development of bendway weirs for the Dogtooth Bend Reach, Mississippi River; hydraulic model investigation," Technical Report HL-94-10, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

along with the resulting benefits in the bend, there may be an improvement in the channel immediately downstream of the bend. This improvement in the downstream channel was due to the redirection of the currents leaving the weir field. Although the upstream approach to the I-40 Highway bridge is not a true bend, this study was conducted to determine if bendway weirs would redirect the flow and increase the velocity along the face of Mud Island upstream of the bridge to reduce the tendency for the channel to shoal above the bridge. Plan G consisted of seven weirs constructed at a crest elevation of -30. The weirs extended from the left bank and were spaced 304.8 m (1,000 ft) apart along the bank. Weir 1, the most upstream weir, was angled -0.05 rad (-3 deg)[1] from perpendicular to the bank line at its origin and the remaining weirs were angled from perpendicular to the bank line 0.10, 0.12, 0.35, 0.35, 0.35, and 0.35 rad (6, 7, 20, 20, 20, and 20 deg), respectively, from upstream to downstream. The resulting lengths of the weirs were 312.4, 309.4, 281.9, 260.6, 243.3, 289.6, and 251.5 m (1,025, 1,015, 925, 855, 795, 950, and 825 ft), respectively. The weirs were installed in the bed configuration obtained at the end of Plan F-Modified run 7. The model conditions before initiation of Plan G are shown in Plate 28. The results of the bendway weir study for the St. Louis District[1] also indicated that the gross effect of the weirs would occur during the initial one or two runs of the model hydrograph. Based on these findings, the model was operated for only two runs of the typical annual hydrograph to evaluate any bendway weir plan.

Results. The results after run 2 are shown in Plate 29. The results indicated a shoal would form downstream of the weir field along the left bank. The channel was forced to leave the left bank and lay along the ends of the Loosahatchie Bar dikes and then returned to the left bank prior to reaching the I-40 Highway bridge. This was not an acceptable alignment. The results indicated the angle of the weirs caused the currents to cross the river.

Plan G-2

Description. Plan G-2 was a realignment of the weirs of Plan G. The number of weirs, the point at which the weirs were tied to the left bank, the spacing along the bank, and the crest elevation were the same as in Plan G. The weirs were angled 0.26, 0.26, 0.12, 0.14, 0.09, 0.00, and -0.26 rad (15, 15, 7, 8, 5, 0, and -15 deg), respectively, from upstream to downstream. Because of the changes in orientation, the resulting lengths of the weirs were 332.2, 320.0, 281.9, 243.8, 228.6, 283.5, and 195.1 m (1,090, 1,050, 925, 800, 750, 930, and 640 ft), respectively. As in Plan G, the weirs were installed in the bed configuration obtained after Plan F-Modified run 7 and only two runs of the typical annual hydrograph were used to evaluate the plan. The initial conditions for Plan G-2 are shown in Plate 30.

[1] Positive angles are angled upstream from perpendicular to the bank and negative angles are downstream from perpendicular.

Results. The results after two runs are shown in Plate 31. The results were about the same as with Plan G. A shoal formed just downstream of the weir field and forced the channel to cross to the right along the Loosahatchie Bar dikes. The shoal was not as large or tall as with Plan G, but the alignment produced with this plan was not acceptable. The results indicated that the weirs too strongly influenced current patterns.

Plan G-3

Description. Plan G-3 (Plate 32) was designed to reduce the effectiveness of the weir field. The plan consisted of removing the upstream four weirs from the field. The remaining three weirs were the same in origin on the left bank and the spacing along the bank. The first weir was lowered to crest el -40 and was angled 0.05 rad (3 deg) from normal to the bank line. The second weir was lowered to crest el -35 and was angled 0.09 rad (5 deg) from normal. The third weir was the same as in Plan G-2 at el -30 and angled 0.26 rad (15 deg) from normal. The resulting lengths of the weirs were 160.0, 193.6, and 195.1 m (525, 635, and 640 ft), respectively. As with the previous weir plans, the model operation was begun with the model molded to the bed configuration of Plan F-Modified run 7 and two runs of the hydrograph were used to evaluate the plan.

Results. The results after the second run are shown in Plate 33. The same tendency to shoal downstream of the weir field developed with this plan as with the previous two weir plans. The shoal was not as severe as with the previous plans, but did tend to force the channel to cross toward the right. Like the other plans, the channel along the Mud Island (left bank) shoaled above el -20. Based on the evaluation of the model results obtained for Plans G, G-2, and G-3, bendway weirs upstream of the I-40 Highway bridge will not improve the upstream approach to the bridge. The results indicated the weirs could result in the loss of a navigation channel upstream of the bridge.

4 Analysis of Results and Conclusions

Analysis of Study Results

The ability of a physical movable-bed model to predict conditions that can be expected to develop in the prototype is highly dependent upon its limitations and the success of the model verification effort. In analysis and evaluation of the results of this study, the inability to scale all pertinent phenomena and the limitations of the model should be considered based on the model verification, base conditions, hydrographs used, and the condition of the model bed at the time the plan or modification was installed. During the verification described in this report, the degradation of the bar on the right side of the channel near the Redman Point Bar Dikes tended to be less in the model, but aggradation in the channel downstream of the Redman Point Bar dikes was greater. The right side of the channel from the ends of the Loosahatchie Bar dikes to the I-40 Highway bridge tended to be deeper in the prototype than reproduced in the model. The model bed tended to be deeper than the prototype from the I-40 Highway bridge to the end of the model. These tendencies should be considered in the evaluation of the model results.

The evaluation of an improvement plan or modification should be based on only those changes caused by the plan or modification compared with the results produced in the model during verification or operation for base conditions. It should be considered that the model reproduced bed material movement only without any attempt to reproduce the movement of material in suspension or its effect on the channel development. Another consideration in the evaluation of model results is that the bank lines in the model were fixed, and no attempt was made to reproduce the erodibility of the banks or sandbars. Also to be considered are that the typical annual and 1973 flood hydrographs used during this study could be considerably different from what actually occurs on the river in the future, and that the model surveys were always made during the low-water period.

Conclusions

The conclusions developed from the results of the model study are summarized as follows:

a. A navigation channel 6.1 m (20 ft) below the LWRP for the base conditions, a "do-nothing" condition, was not maintained for the typical annual hydrograph. The upstream approach to the I-40 Highway bridge shoaled.

b. The higher stages and resulting velocities of the 1973 hydrograph did not significantly change the navigation channel alignment or depths obtained with the typical annual hydrograph for the base conditions.

c. The Master Plan dikes did not produce a low-water (el -20) navigation channel, and the channel was only slightly improved from the channel developed during base conditions.

d. The Master Plan dikes caused scour at the toe of the left bank immediately downstream of the entrance to the Memphis Harbor. The scour could further decrease the already poor stability of the bank and could result in failure of the bank.

e. Because of the very low stability ratio of the bank downstream of the Memphis Harbor entrance, it is recommended that the proposed stability berm be constructed prior to any additional dike construction in the Hopefield Point area.

f. The stability berm study was conducted with the proposed stability berm and only the existing prototype dikes in place. The results showed the berm alone would not significantly improve the navigation channel conditions and the impacts that occurred were confined to the area around the berm.

g. After the model was extended, verification and base condition experiments were conducted because of the change in the upstream entrance to the model. The extended model base conditions were conducted with the stability berm in place. The navigation channel upstream of mile 745.0 was too shallow and poorly aligned. The upstream approach to the I-40 Highway bridge was improved, but the channel became very narrow at the upstream end of the berm.

h. Plans A, B, and C were a progression of modifications that produced a much improved navigation channel upstream of mile 745.0, but caused shoaling in the upstream approach to I-40 Highway bridge that resulted in the channel being shifted to the right side of the river.

i. Plans D, E, F, and F-Modified, provided by the Memphis District, reflected structures that had been constructed in the prototype after the April 1990 prototype survey was obtained and changes in the design of structures to be constructed. Plan F-Modified was the final design and produced a satisfactory navigation channel, but as with all plans evaluated during this study, this plan showed a tendency to shoal in the upstream approach to the I-40 Highway bridge.

j. Plans G, G-2, and G-3 included bendway weirs placed upstream of the I-40 Highway bridge to reduce the tendency to shoal in the approach to the bridge. The bendway weirs did not improve the bridge approach.

Table 1
Verification Hydrograph, 15 January to 30 November 1986

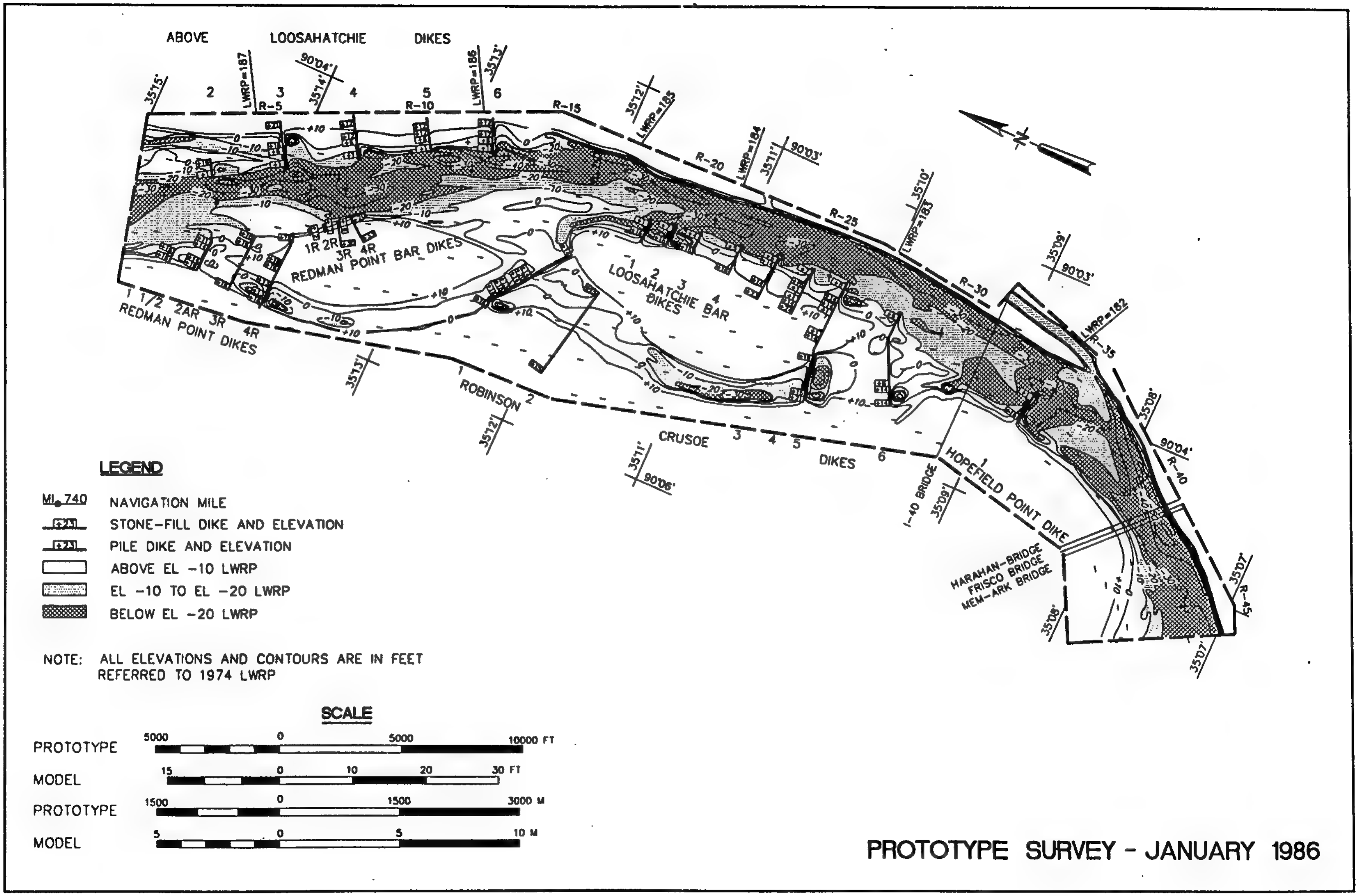
Hydrograph Flow No.	Memphis Stage ft LWRP	Discharge		Duration days
		cu m/sec	cfs	
1	6	8,496	300,000	10
2	13	12,744	450,000	15
3	25	23,506	830,000	18
4	20	19,258	680,000	10
5	15	13,877	490,000	10
6	25	23,506	830,000	13
7	15	13,310	470,000	31
8	12	12,178	430,000	16
9	20	17,842	630,000	30
10	15	13,877	490,000	10
11	8	9,629	340,000	9
12	15	13,310	470,000	10
13	18	15,576	550,000	10
14	10	9,629	340,000	11
15	5	7,363	260,000	25
16	2	6,514	230,000	24
17	15	13,877	490,000	12
18	25	23,506	830,000	16
19	19	16,992	600,000	19
20	23	19,824	700,000	10
21	15	13,877	490,000	10

Table 2
Typical Annual Hydrograph

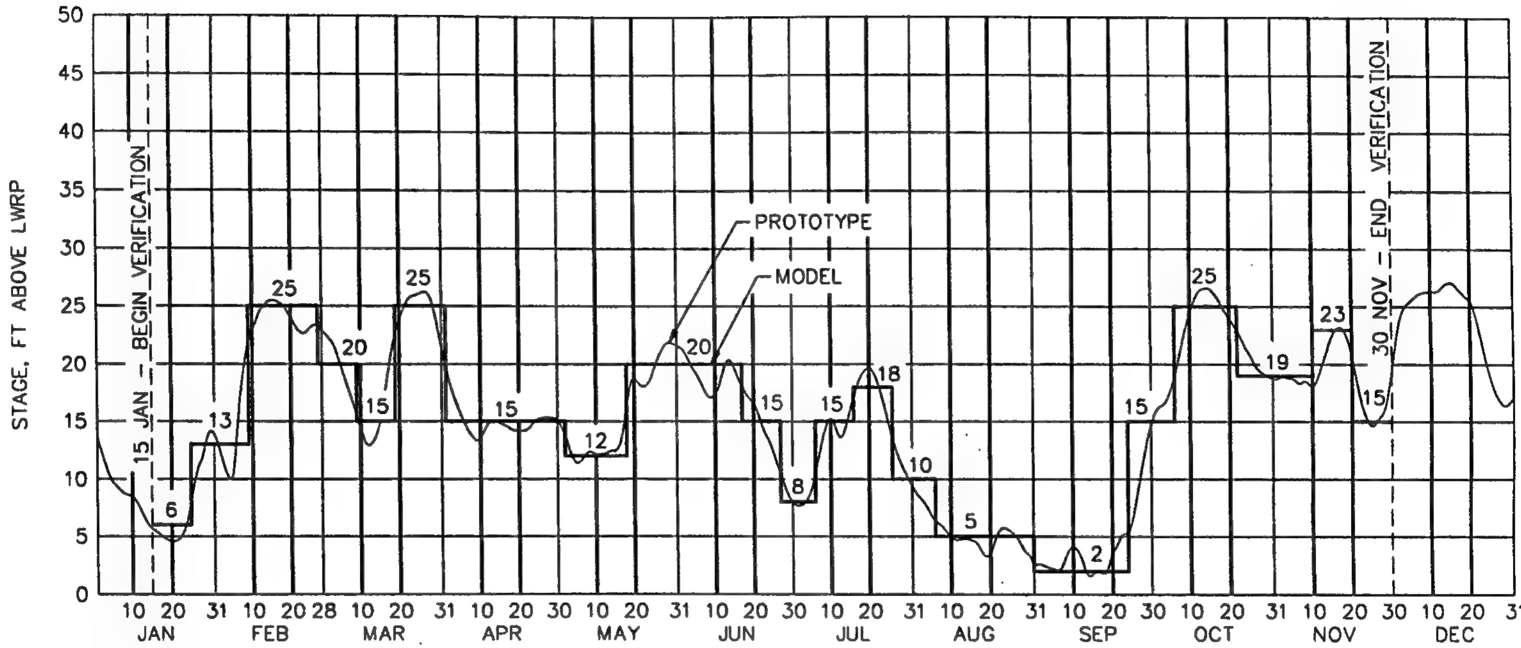
Hydrograph Flow No.	Memphis Stage ft LWRP	Discharge		Duration days
		cu m/sec	cfs	
1	5	7,646	270,000	36
2	10	10,620	375,000	58
3	15	13,877	490,000	31
4	20	17,842	630,000	24
5	15	13,877	490,000	33
6	25	23,222	820,000	26
7	30	29,736	1,050,000	29
8	35	35,966	1,270,000	18
9	30	29,736	1,050,000	9
10	20	17,842	630,000	15
11	25	23,222	820,000	10
12	15	13,877	490,000	12
13	10	10,620	375,000	26
14	5	7,646	270,000	38

Table 3
1973 Flood Hydrograph

Hydrograph Flow No.	Memphis Stage ft LWRP	Discharge		Duration days
		cu m/sec	cfs	
1	30	29,736	1,050,000	15
2	20	17,842	630,000	10
3	25	23,222	820,000	12
4	30	29,736	1,050,000	19
5	20	17,842	630,000	15
6	30	29,736	1,050,000	10
7	40	42,480	1,500,000	59
8	35	35,966	1,270,000	10
9	30	29,736	1,050,000	17
10	25	23,222	820,000	12
11	20	17,842	630,000	15
12	15	13,877	490,000	12
13	20	17,842	630,000	11
14	10	10,620	375,000	26
15	5	7,646	270,000	32
16	15	13,877	490,000	34
17	10	10,620	375,000	17
18	20	17,842	630,000	11
19	30	29,736	1,050,000	14
20	20	17,842	630,000	14

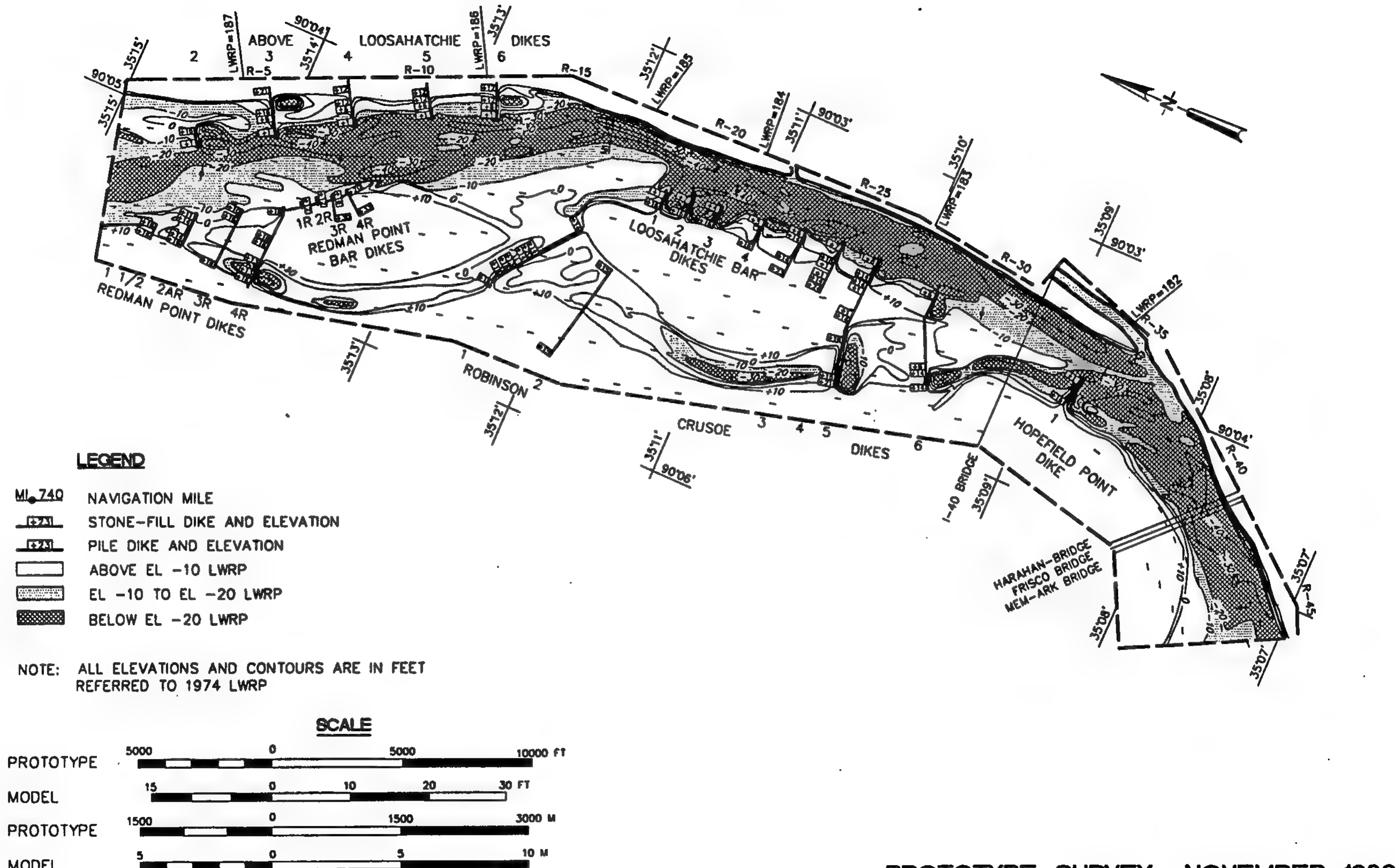


PROTOTYPE SURVEY - JANUARY 1986

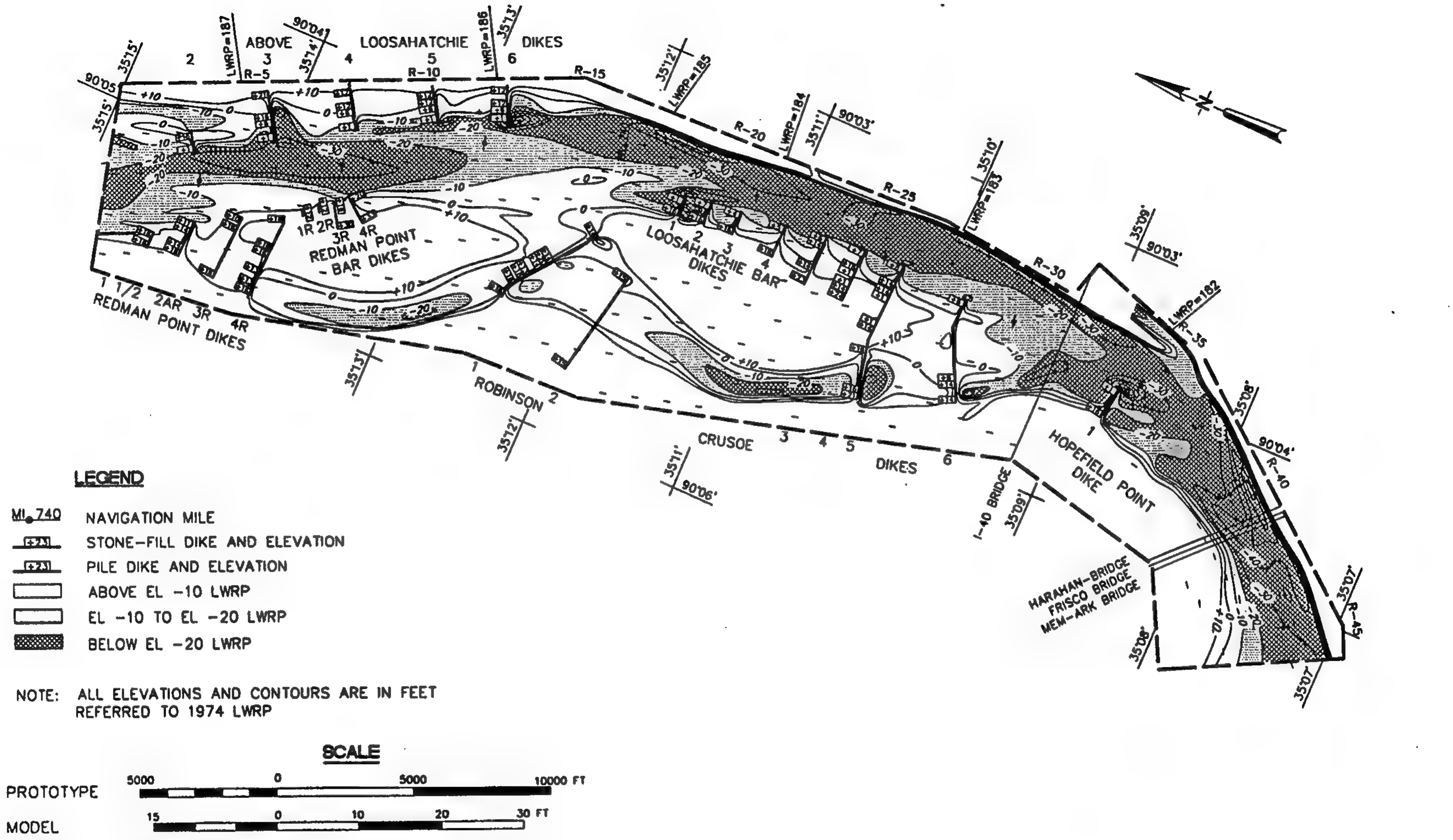


NOTE: VALUES SHOWN ON HYDROGRAPH
ARE STAGES IN FEET LWRP

VERIFICATION HYDROGRAPH - 1986 PROTOTYPE

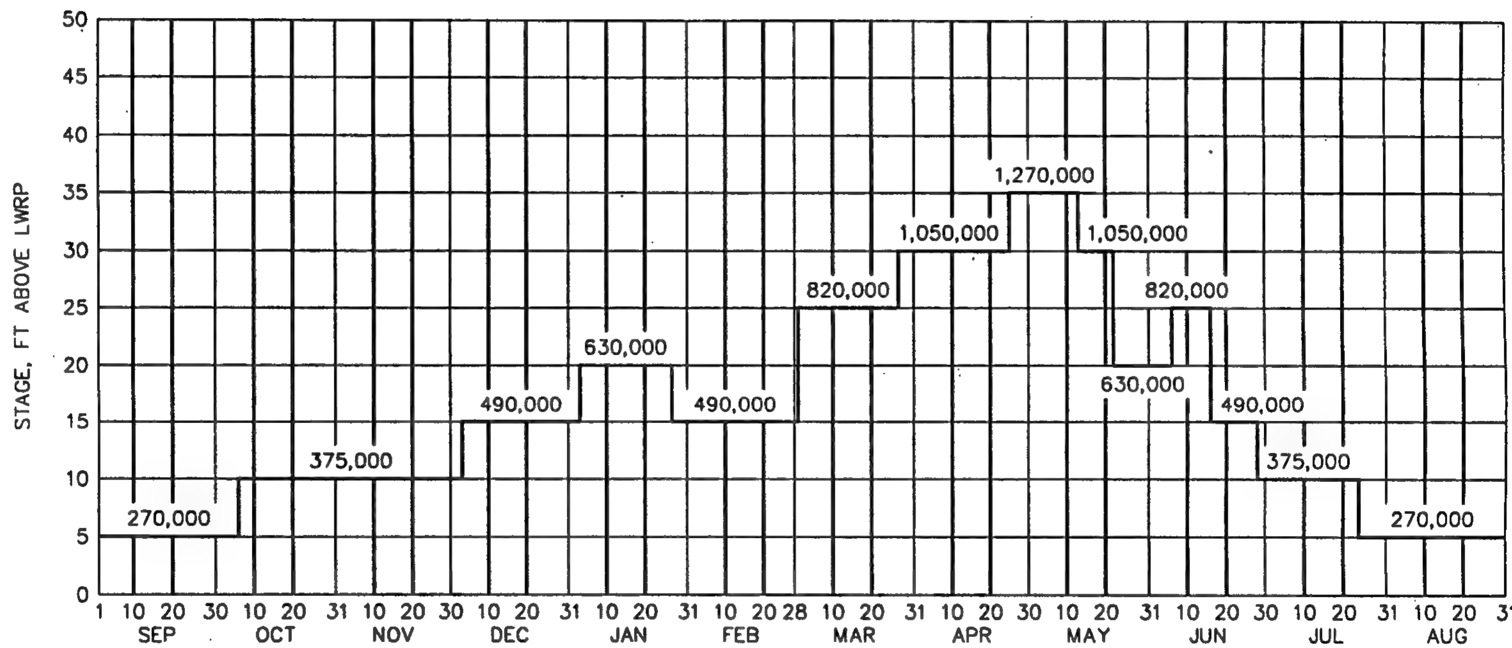


PROTOTYPE SURVEY - NOVEMBER 1986



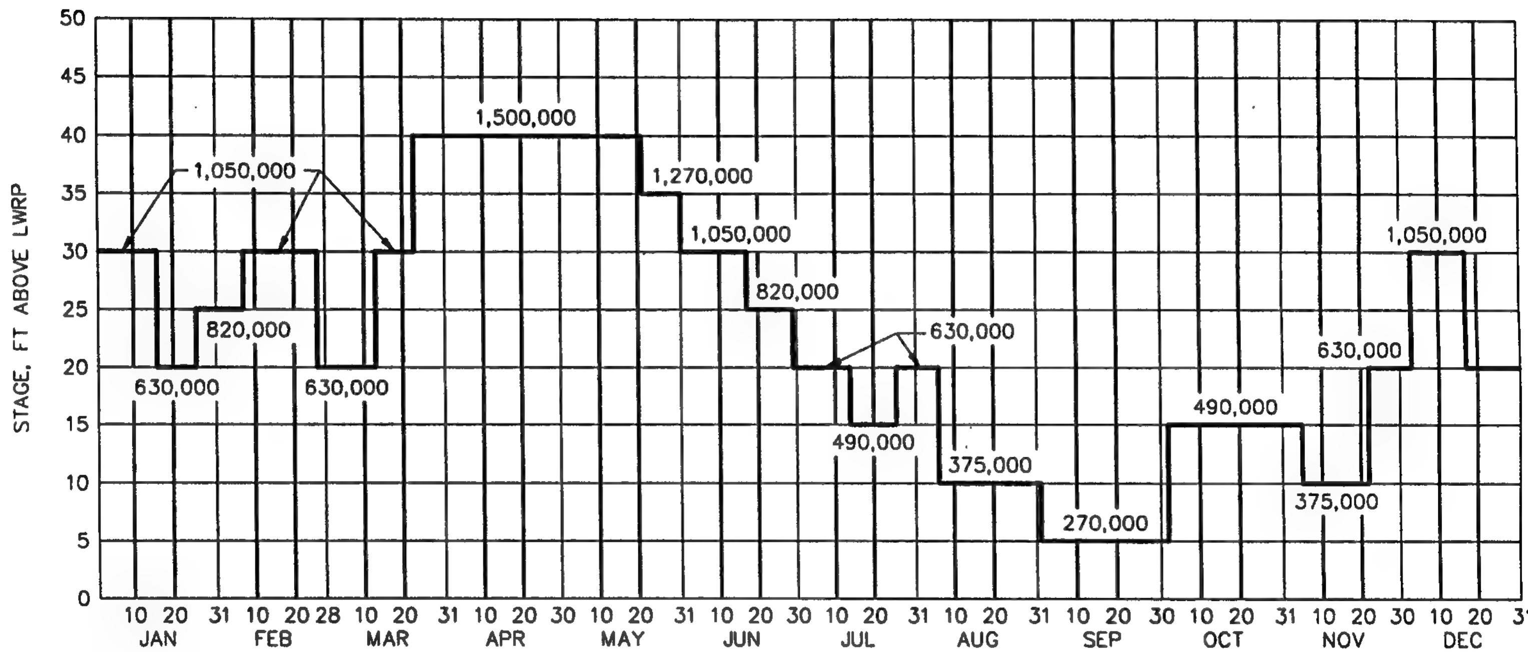
MODEL CHANNEL CONFIGURATION
VERIFICATION

Plate 4



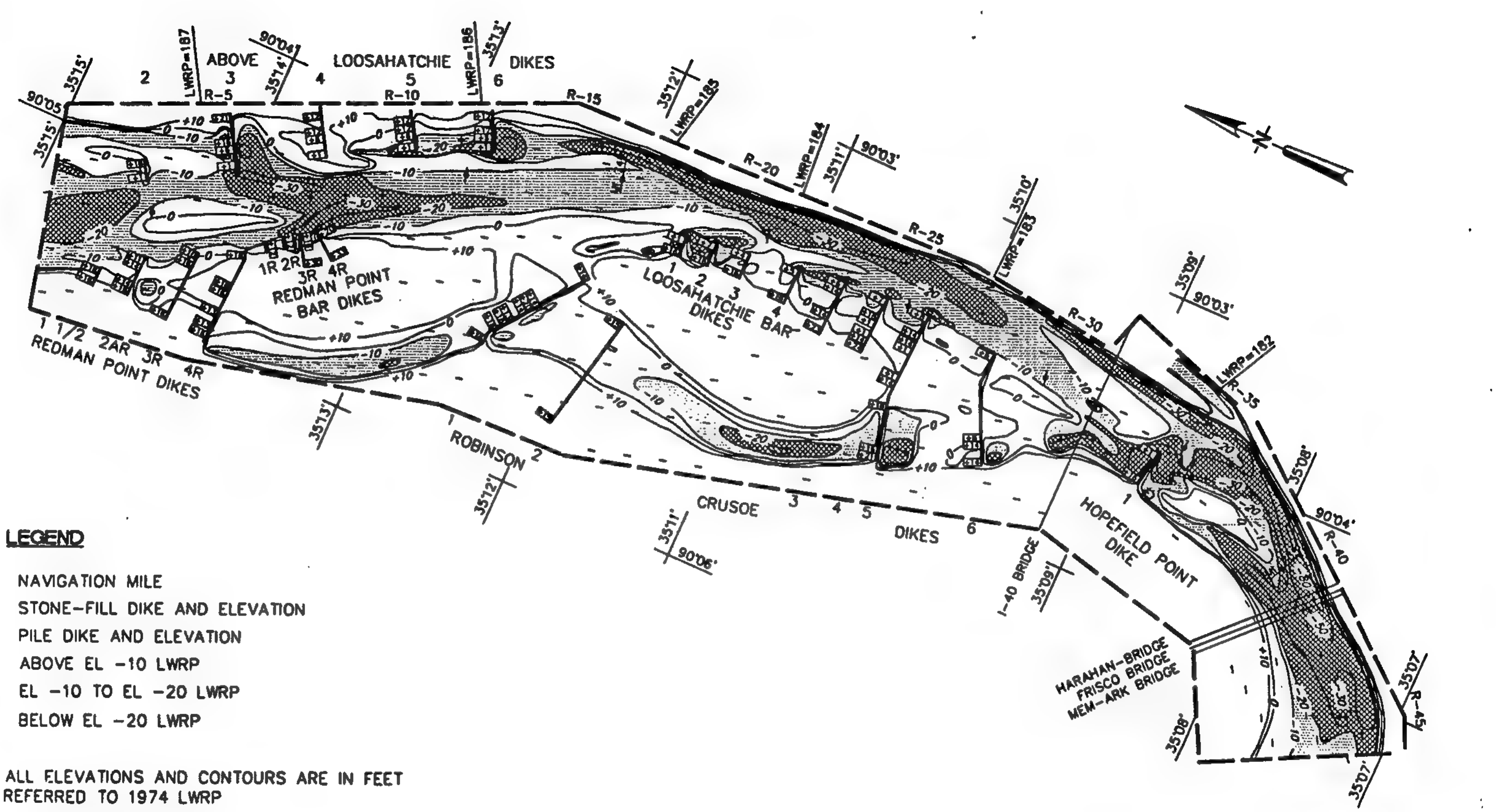
NOTE: VALUES SHOWN ON HYDROGRAPH
ARE PROTOTYPE DISCHARGES IN CFS

TYPICAL ANNUAL HYDROGRAPH



NOTE: VALUES SHOWN ON HYDROGRAPH
ARE PROTOTYPE DISCHARGES IN CFS

FLOOD HYDROGRAPH - 1973 PROTOTYPE



LEGEND

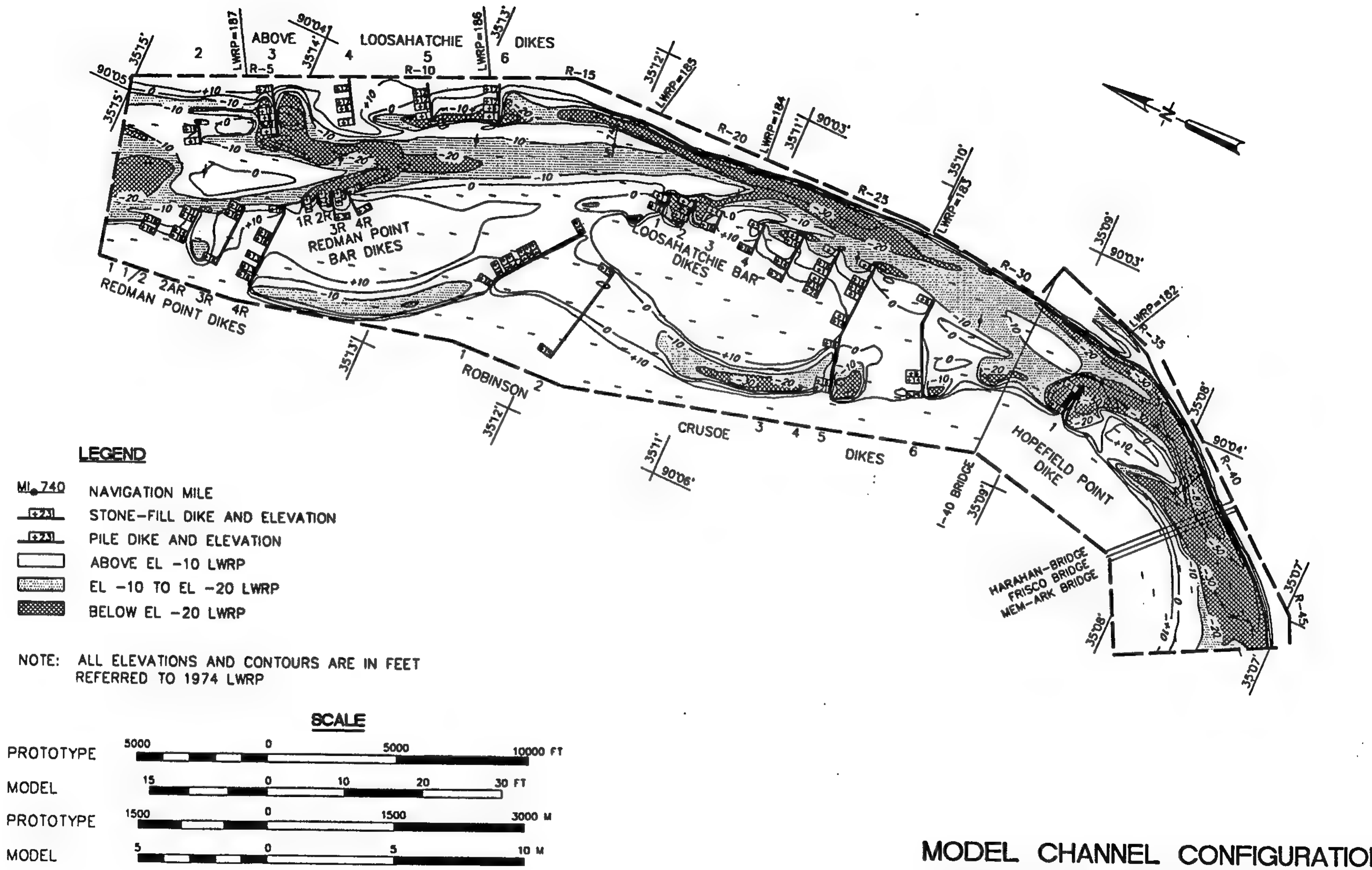
MI 740	NAVIGATION MILE
+23	STONE-FILL DIKE AND ELEVATION
+23	PILE DIKE AND ELEVATION
	ABOVE EL -10 LWRP
	EL -10 TO EL -20 LWRP
	BELOW EL -20 LWRP

NOTE: ALL ELEVATIONS AND CONTOURS ARE IN FEET REFERRED TO 1974 LWRP

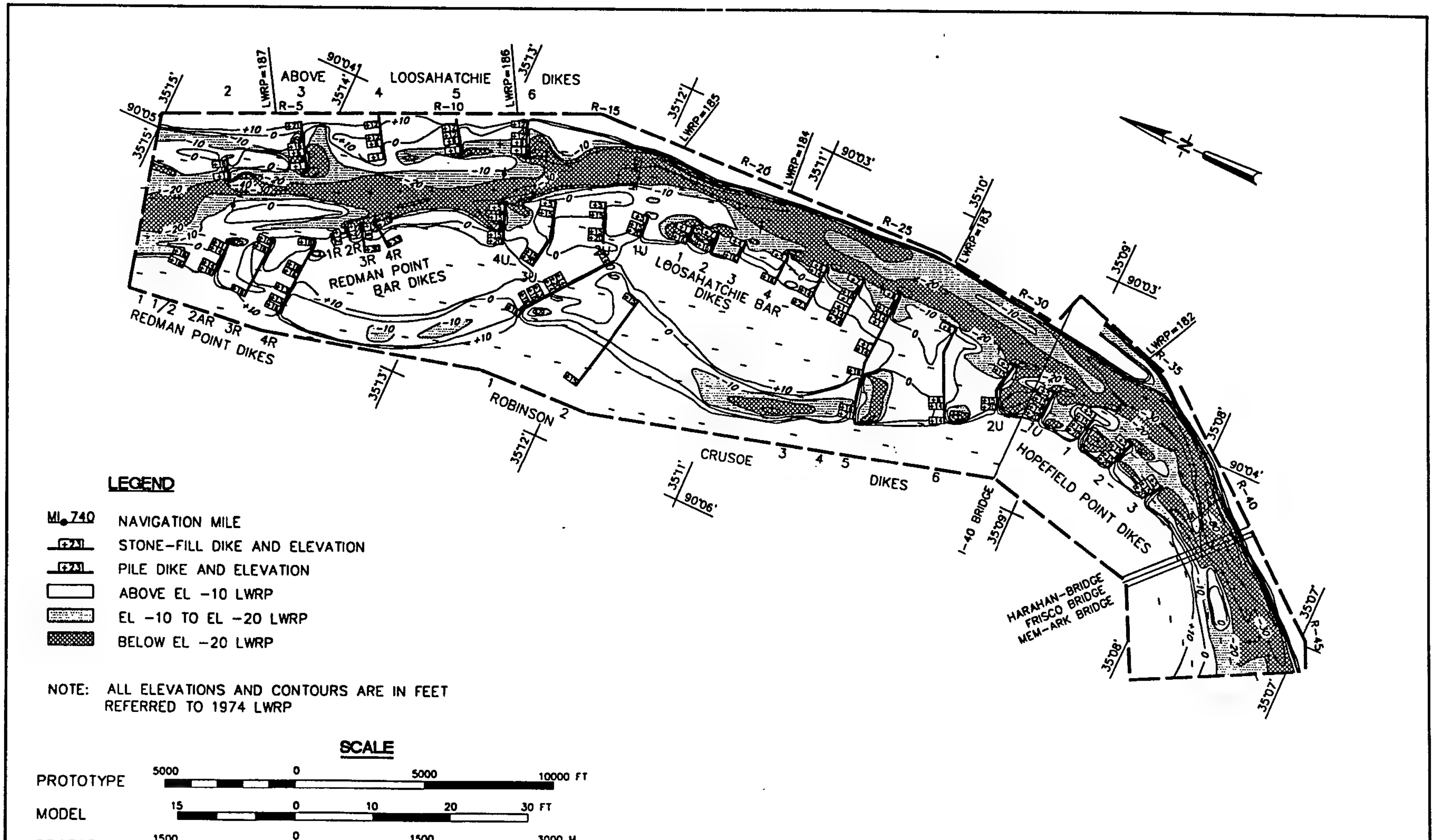
SCALE

PROTOTYPE	5000	0	5000	10000 FT
MODEL	15	0	10 20	30 FT
PROTOTYPE	1500	0	1500	3000 M
MODEL	5	0	5	10 M

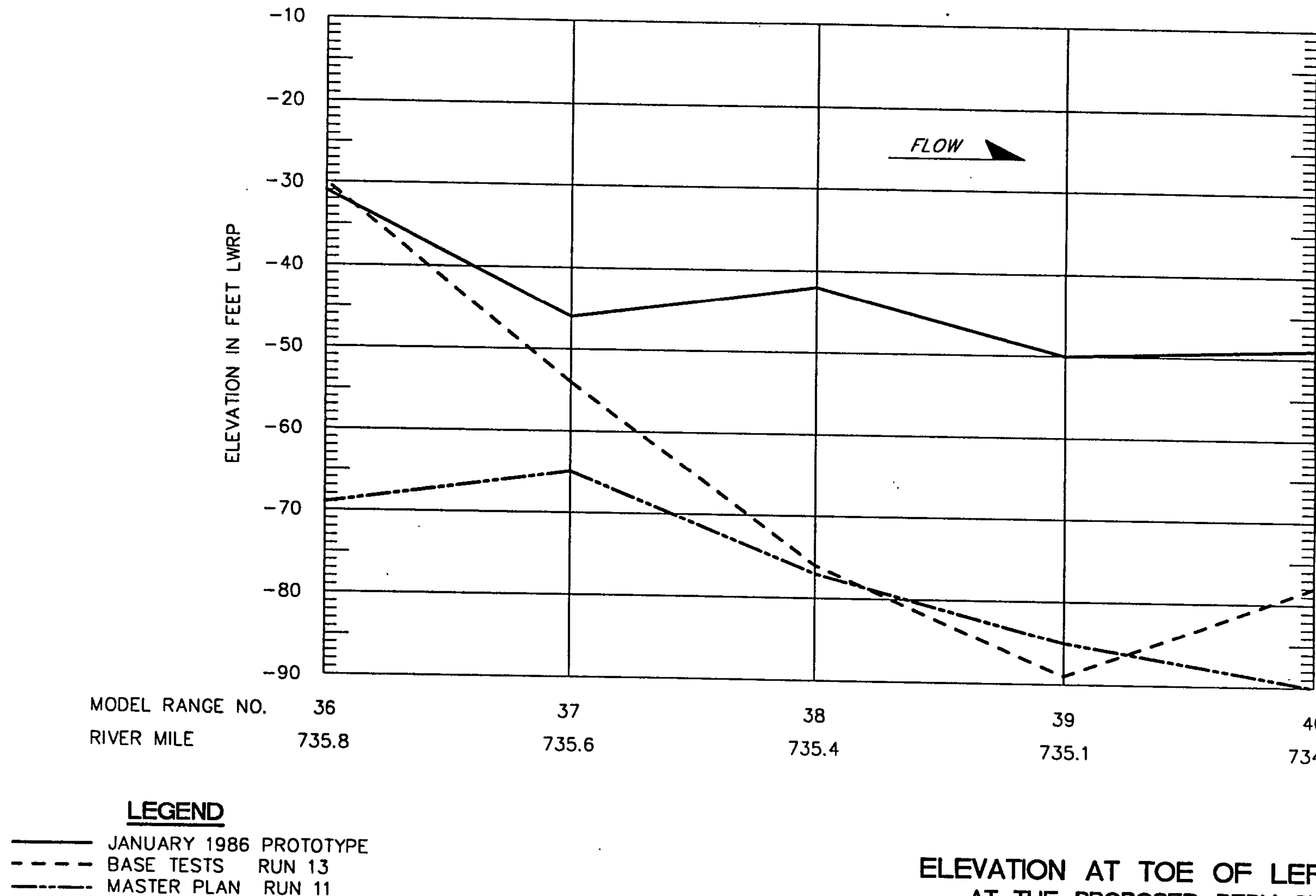
MODEL CHANNEL CONFIGURATION
BASE CONDITIONS - RUN 13



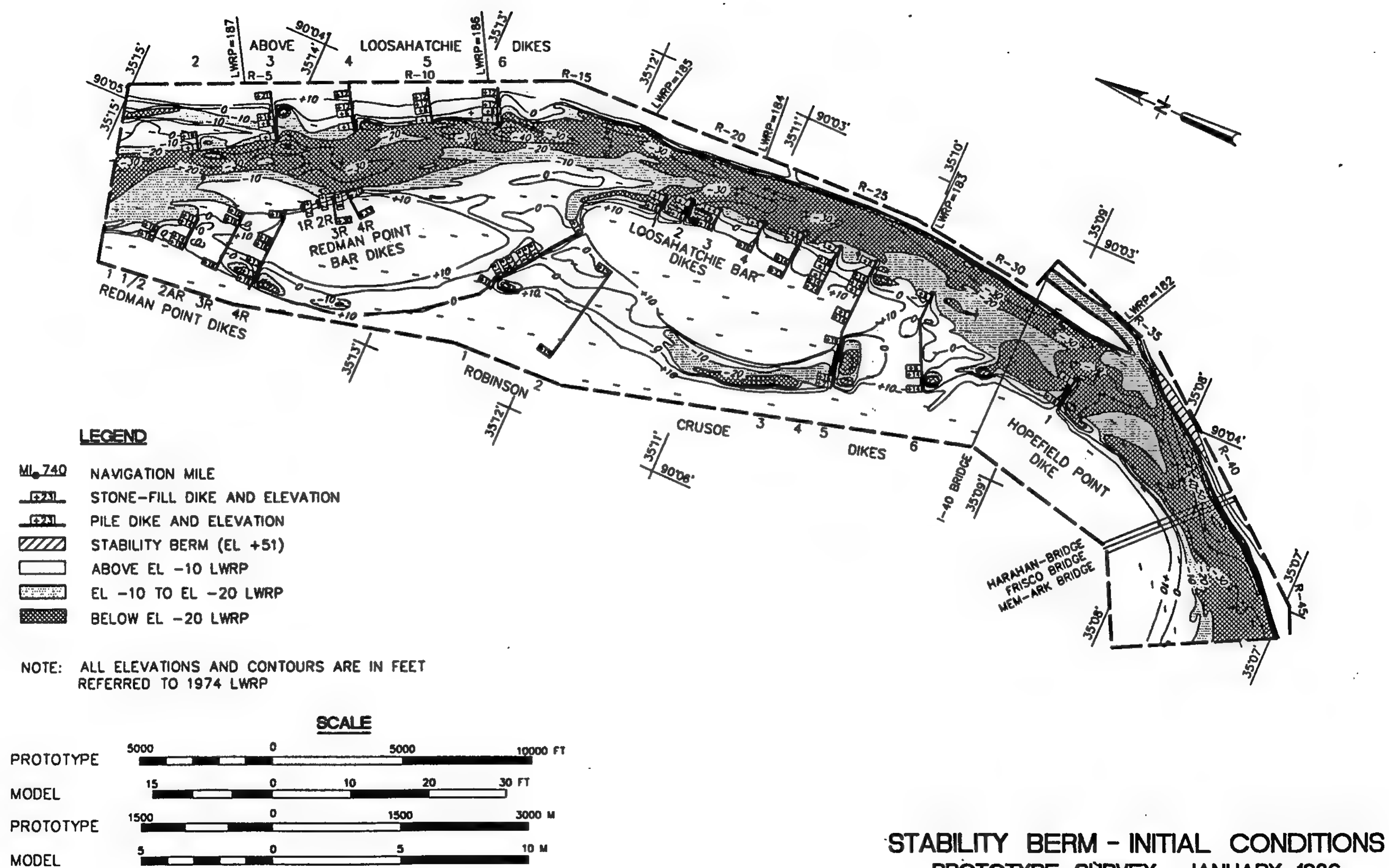
MODEL CHANNEL CONFIGURATION
BASE CONDITIONS - FLOOD HYDROGRAPH



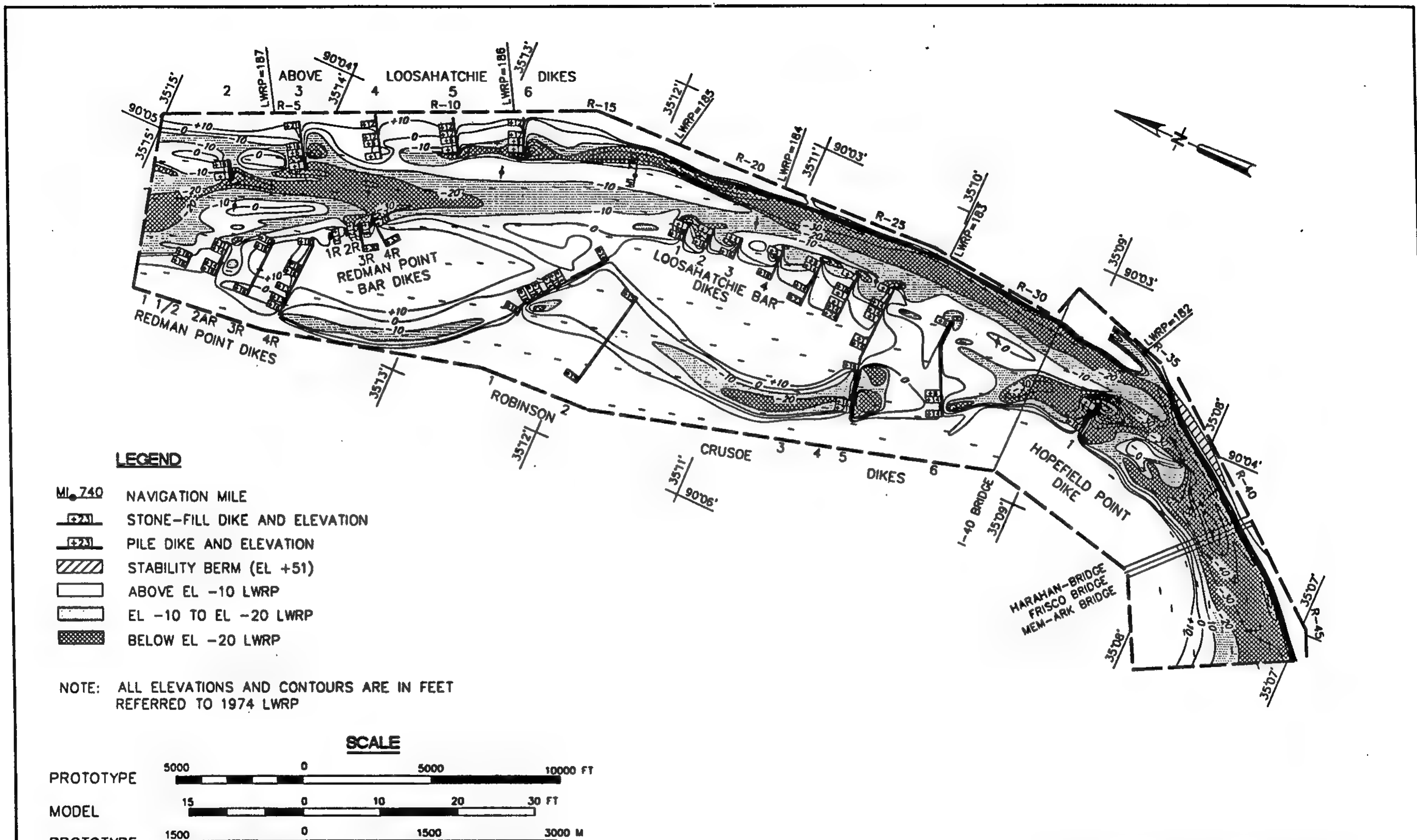
MODEL CHANNEL CONFIGURATION
MASTER PLAN - RUN 11



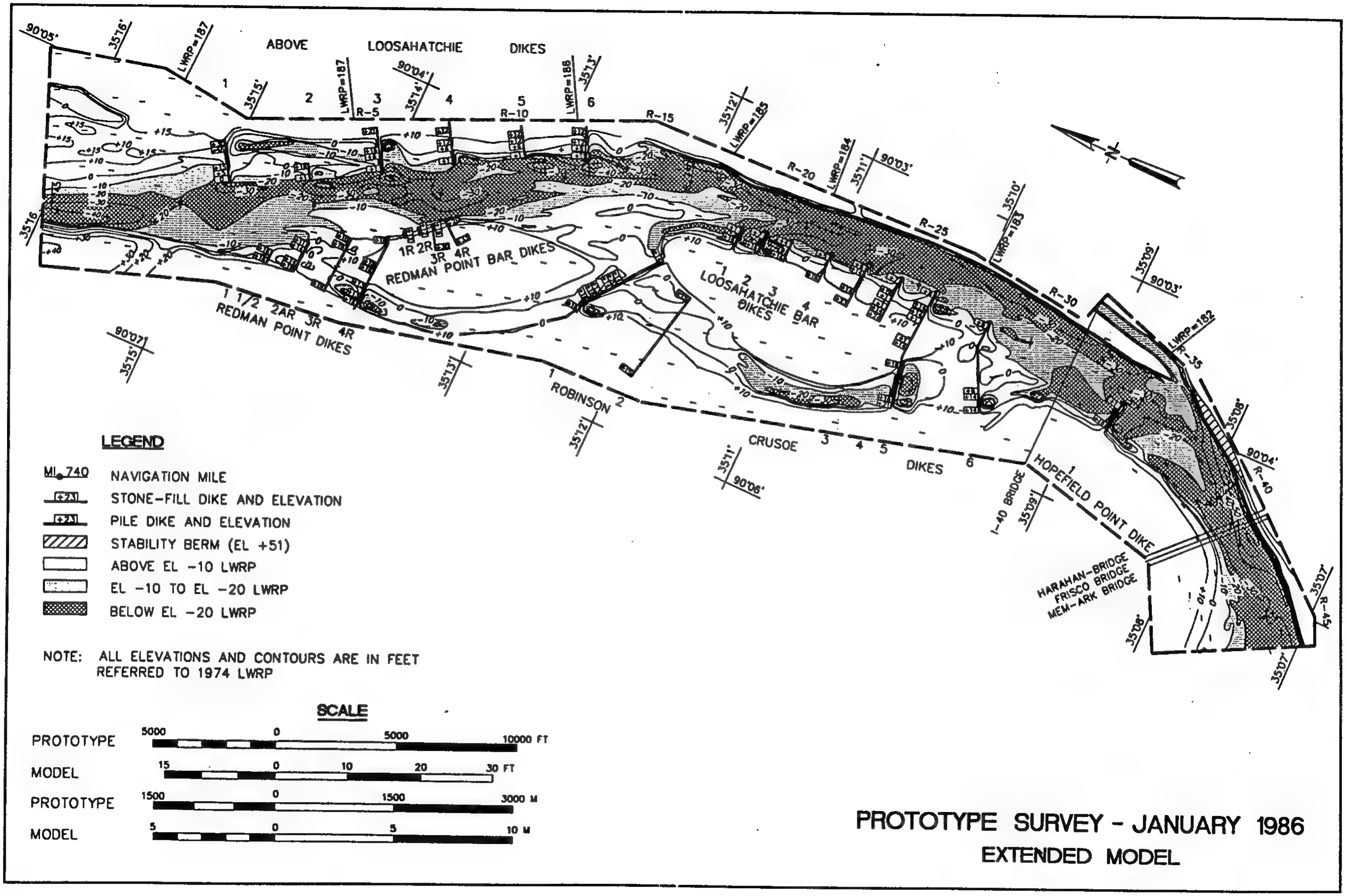
ELEVATION AT TOE OF LEFT BANK
AT THE PROPOSED BERM SIGHT

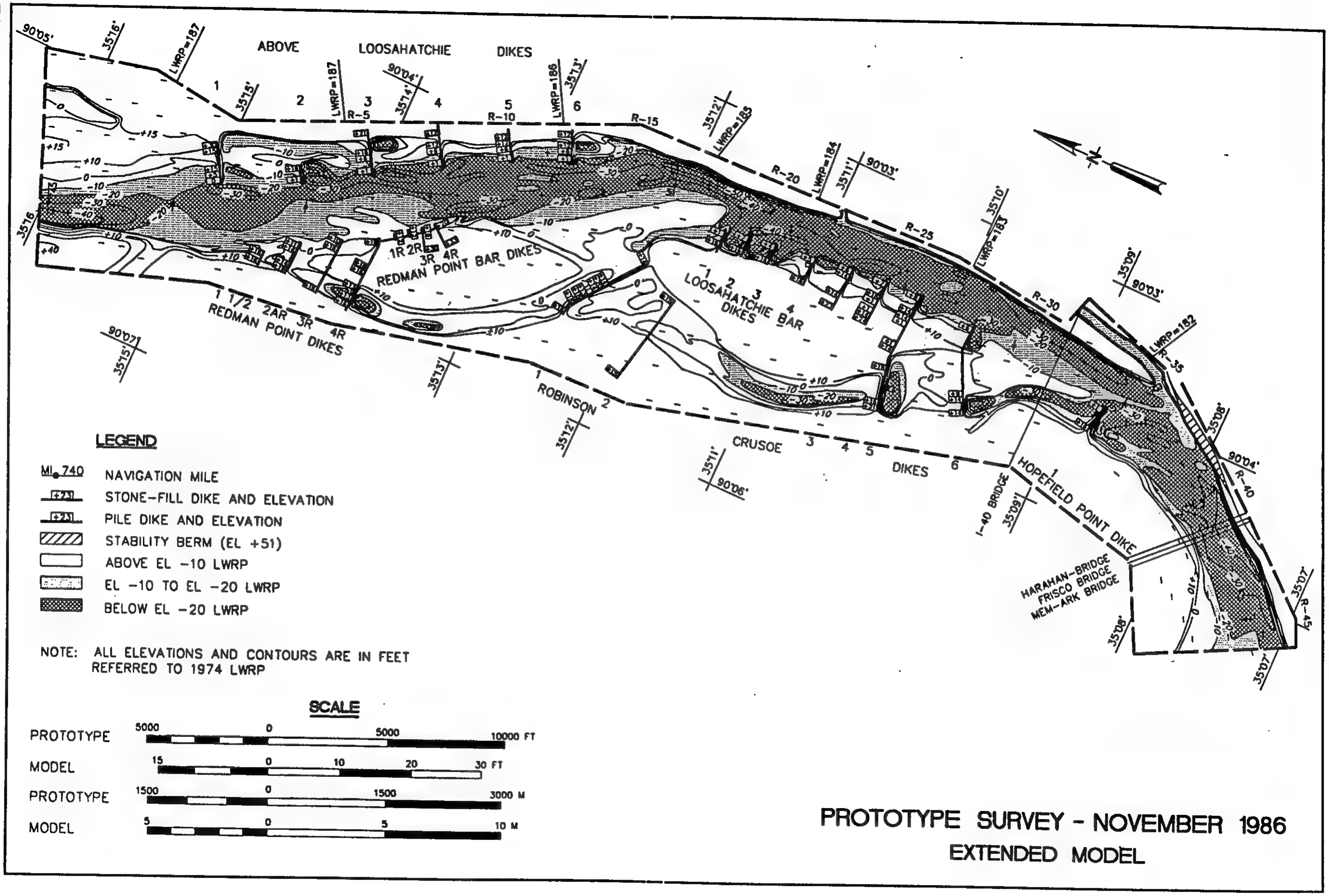


STABILITY BERM - INITIAL CONDITIONS
PROTOTYPE SURVEY - JANUARY 1986



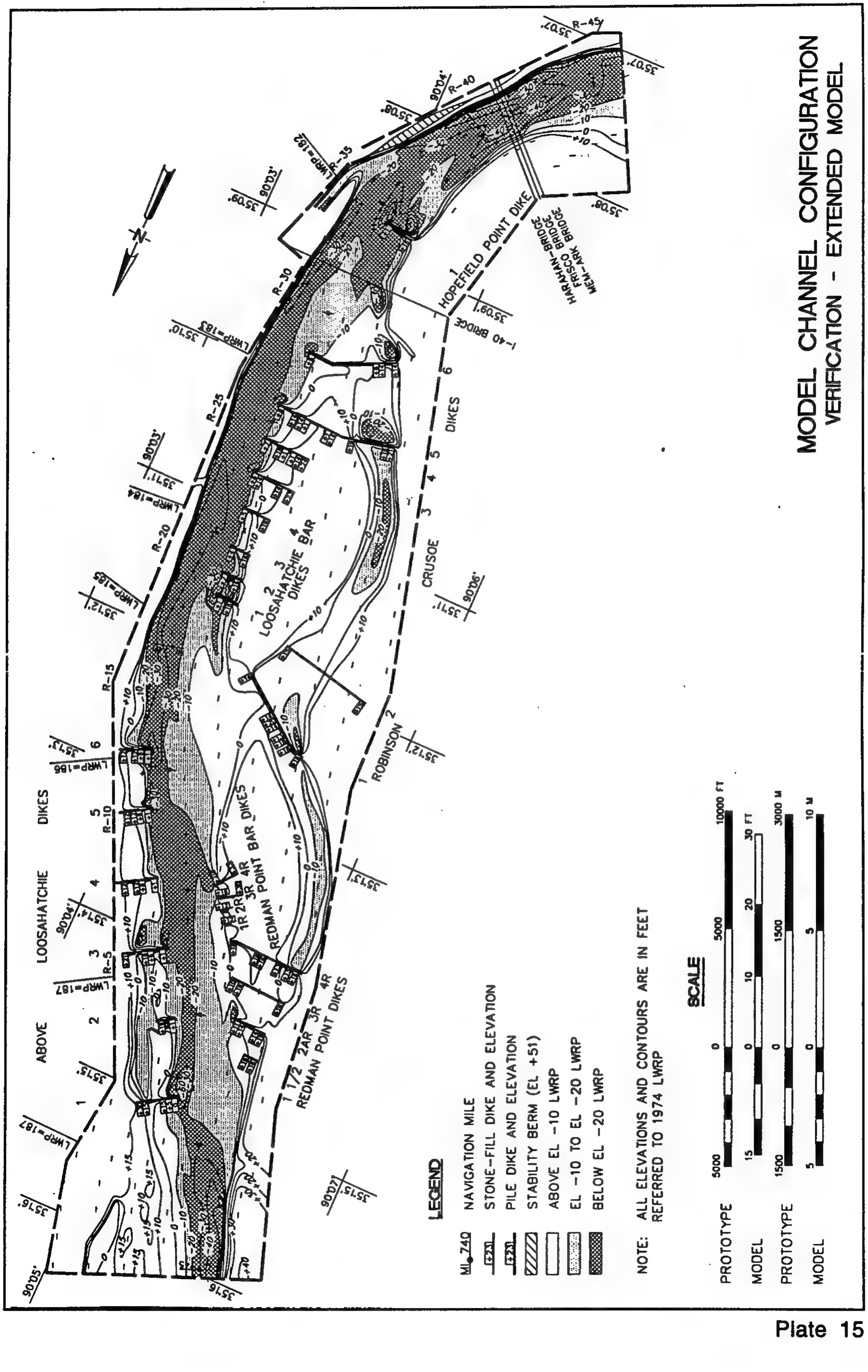
MODEL CHANNEL CONFIGURATION
STABILITY BERM - RUN 7


ABOVE LOOSAHATCHIE DIKES
REDMAN POINT BAR DIKES
1R 2R 3R 4R
REDMAN POINT DIKES
1 1/2 2AR 3R 4R
LOOSAHATCHIE BAR DIKES
ROBINSON
CRUSOE DIKES
HOPEFIELD POINT DIKE
I-40 BRIDGE
HARAHAN BRIDGE
FRISCO BRIDGE
MEM-ARK BRIDGE
LWRP=187
LWRP=186
LWRP=185
LWRP=184
LWRP=183
LWRP=182
R-5
R-10
R-15
R-20
R-25
R-30
R-35
R-40
R-45
N
LEGEND
ML 740 NAVIGATION MILE
+23 STONE-FILL DIKE AND ELEVATION
+23 PILE DIKE AND ELEVATION
STABILITY BERM (EL +51)
ABOVE EL -10 LWRP
EL -10 TO EL -20 LWRP
BELOW EL -20 LWRP
NOTE: ALL ELEVATIONS AND CONTOURS ARE IN FEET REFERRED TO 1974 LWRP
SCALE
PROTOTYPE 5000 0 5000 10000 FT
MODEL 15 0 10 20 30 FT
PROTOTYPE 1500 0 1500 3000 M
MODEL 5 0 5 10 M
PROTOTYPE SURVEY - JANUARY 1986
EXTENDED MODEL

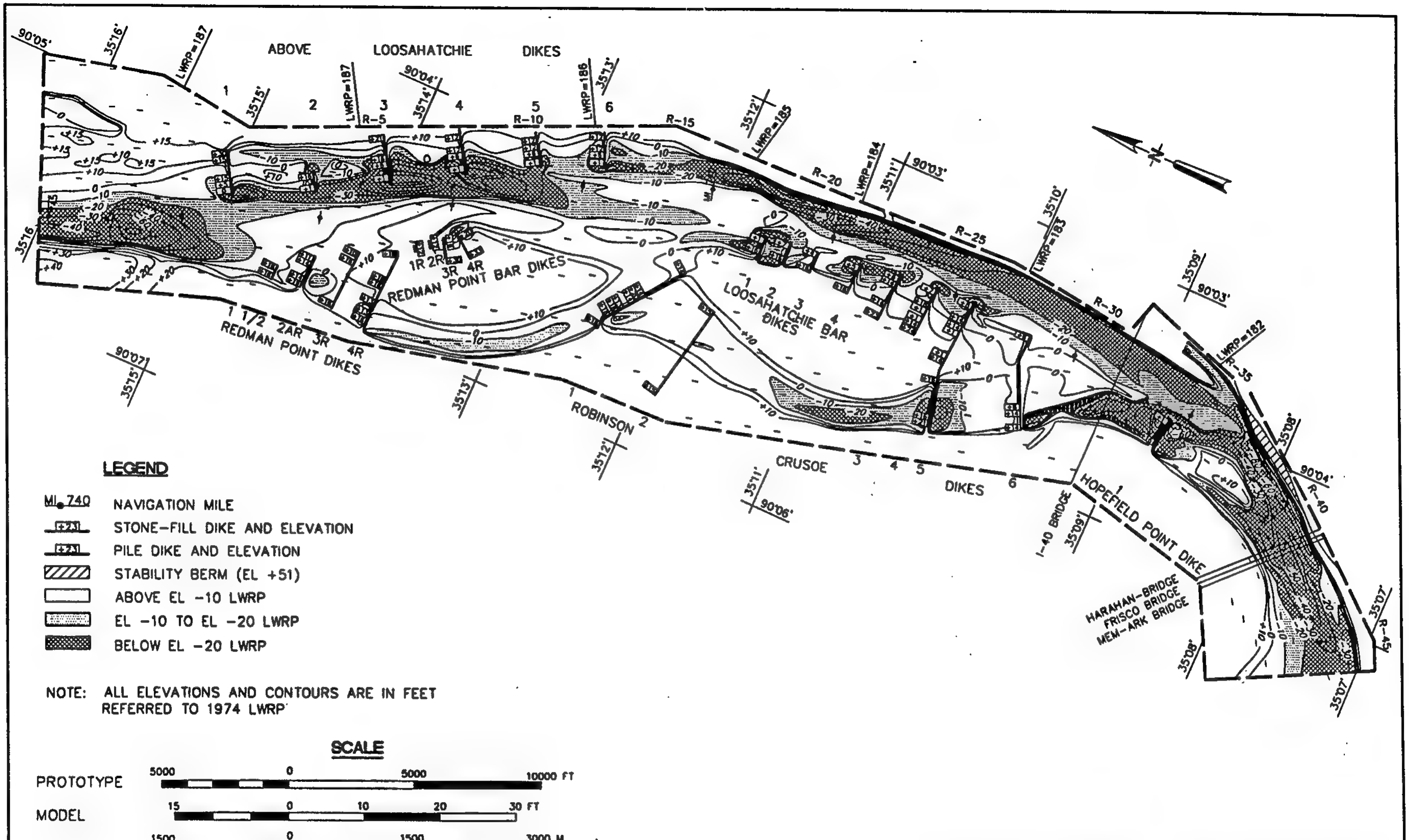


PROTOTYPE SURVEY - NOVEMBER 1986
EXTENDED MODEL

Plate 14

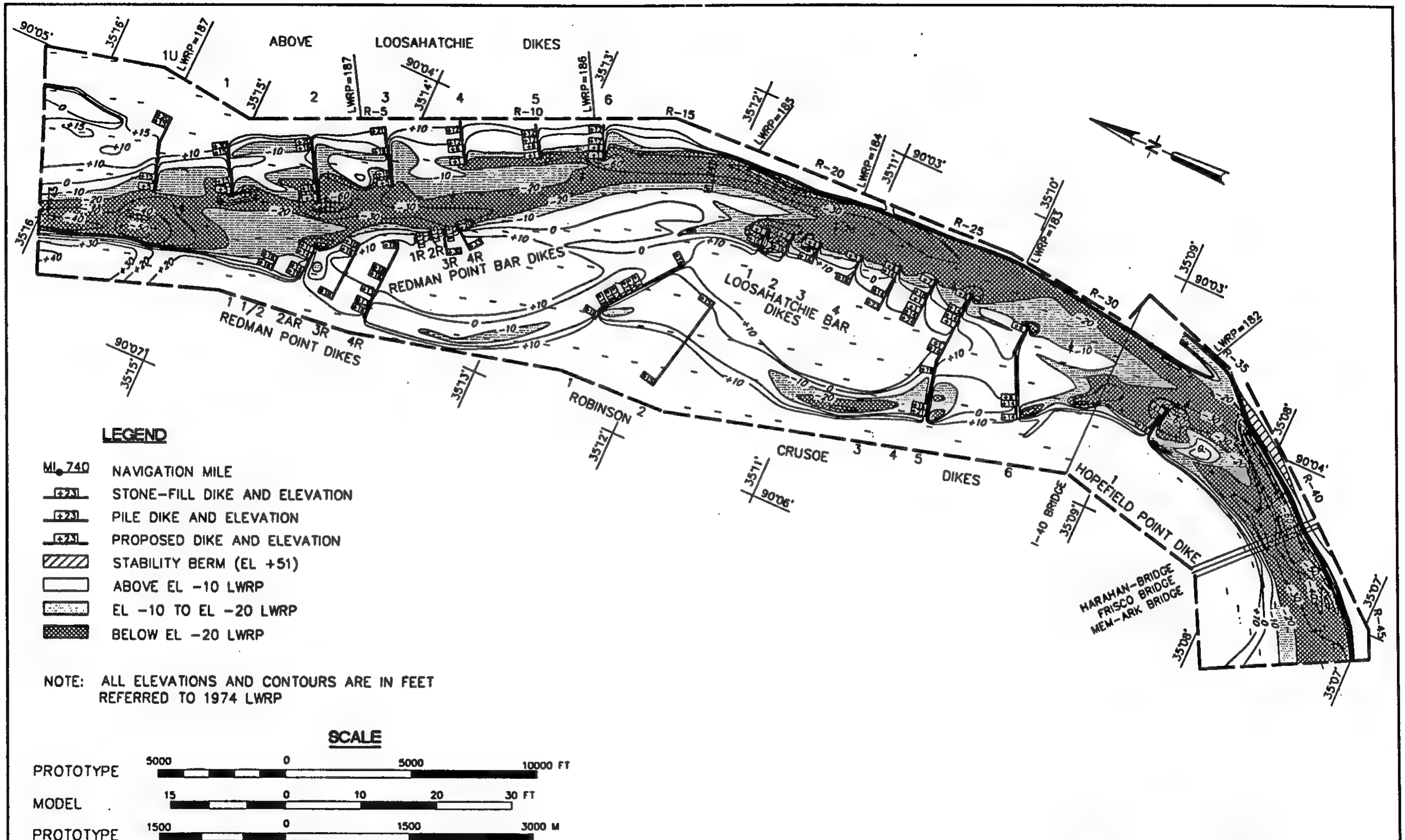


MODEL CHANNEL CONFIGURATION
VERIFICATION - EXTENDED MODEL
LEGEND
MI 740 NAVIGATION MILE
STONE-FILL DIKE AND ELEVATION
PILE DIKE AND ELEVATION
STABILITY BERM (EL +51)
ABOVE EL -10 LWRP
EL -10 TO EL -20 LWRP
BELOW EL -20 LWRP
NOTE: ALL ELEVATIONS AND CONTOURS ARE IN FEET REFERRED TO 1974 LWRP
SCALE
PROTOTYPE 5000 0 5000 10000 FT
MODEL 15 0 10 20 30 FT
PROTOTYPE 1500 0 1500 3000 M
MODEL 5 0 5 10 M
ABOVE LOOSAHATCHIE DIKES
LOOSAHATCHIE BAR DIKES
REDMAN POINT BAR DIKES
REDMAN POINT DIKES
ROBINSON
CRUSOE DIKES
HOPEFIELD POINT DIKE
I-40 BRIDGE
HARAHAN BRIDGE
FRISCO BRIDGE
MEM-ARK BRIDGE

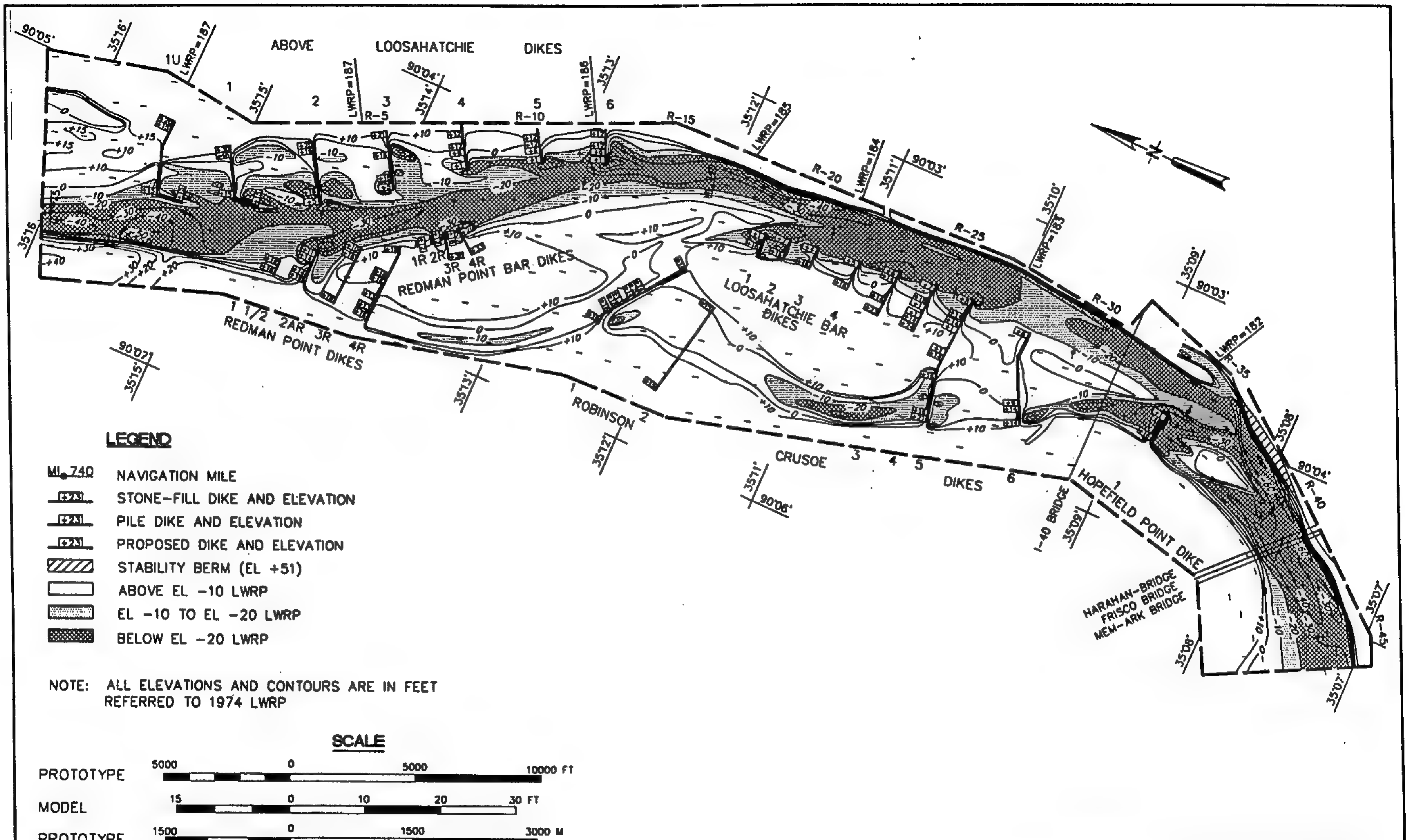


MODEL CHANNEL CONFIGURATION
BASE CONDITIONS - EXTENDED MODEL

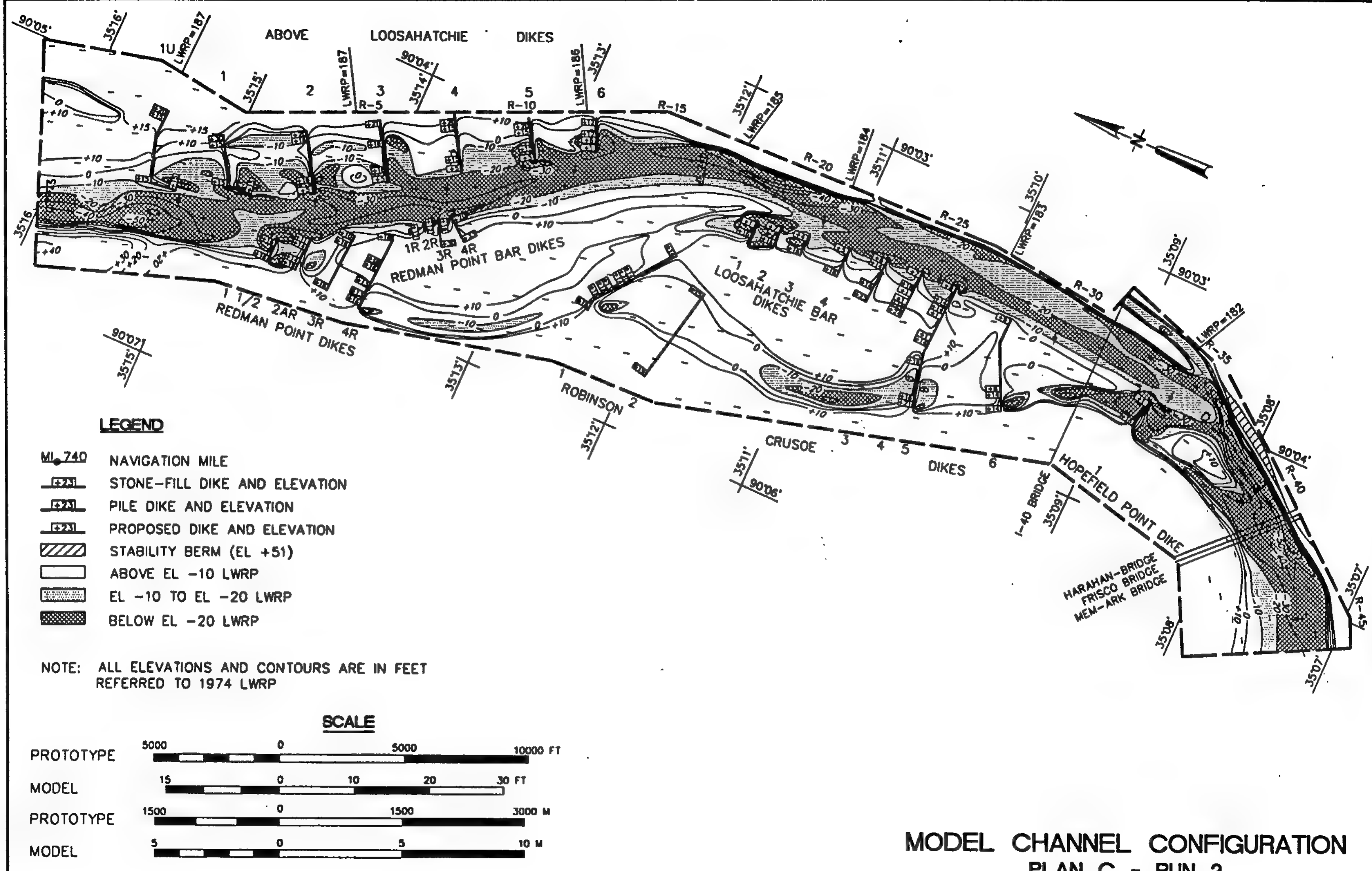
Plate 16



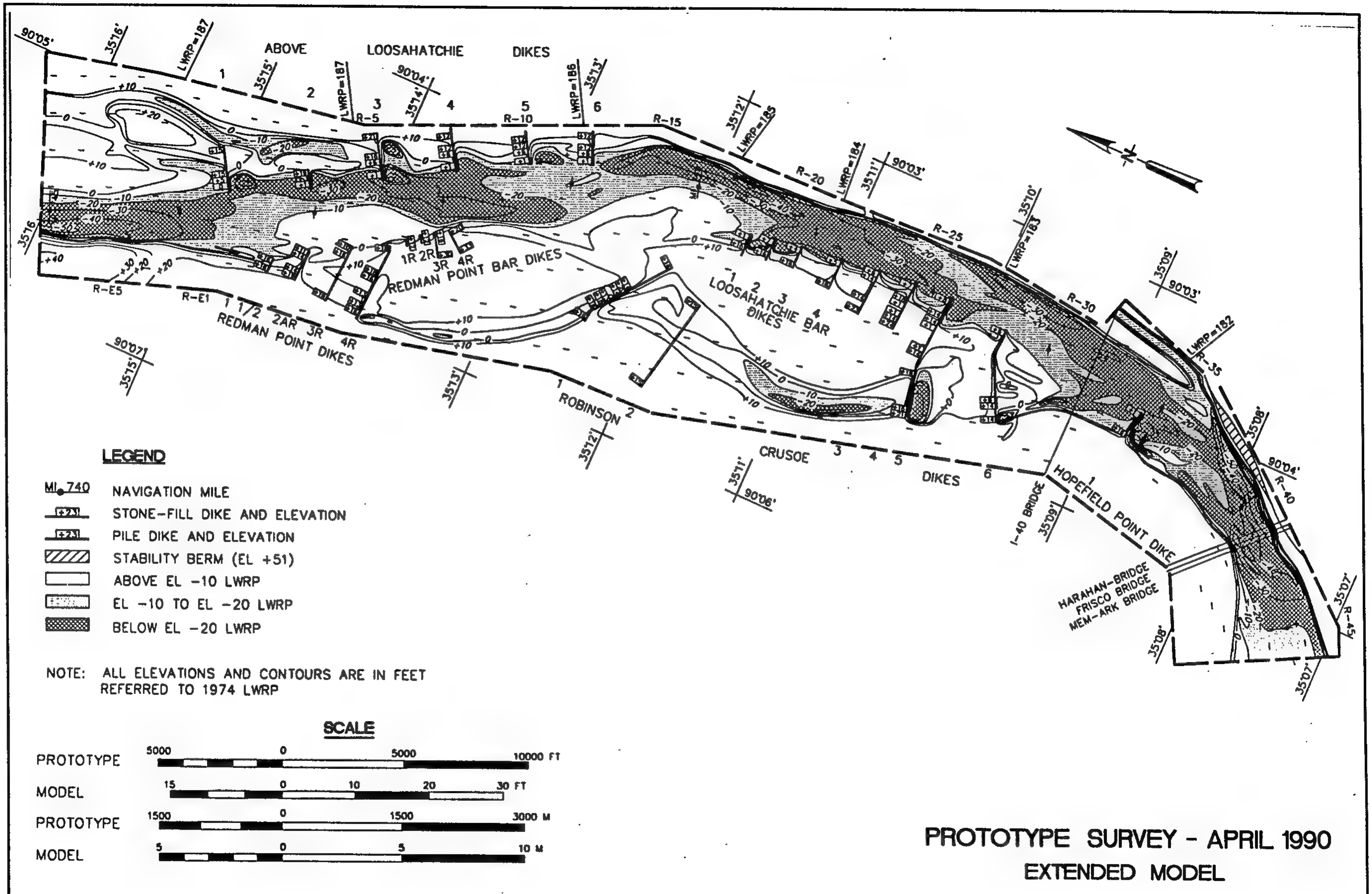
MODEL CHANNEL CONFIGURATION
PLAN A - RUN 2



MODEL CHANNEL CONFIGURATION
PLAN B - RUN 3

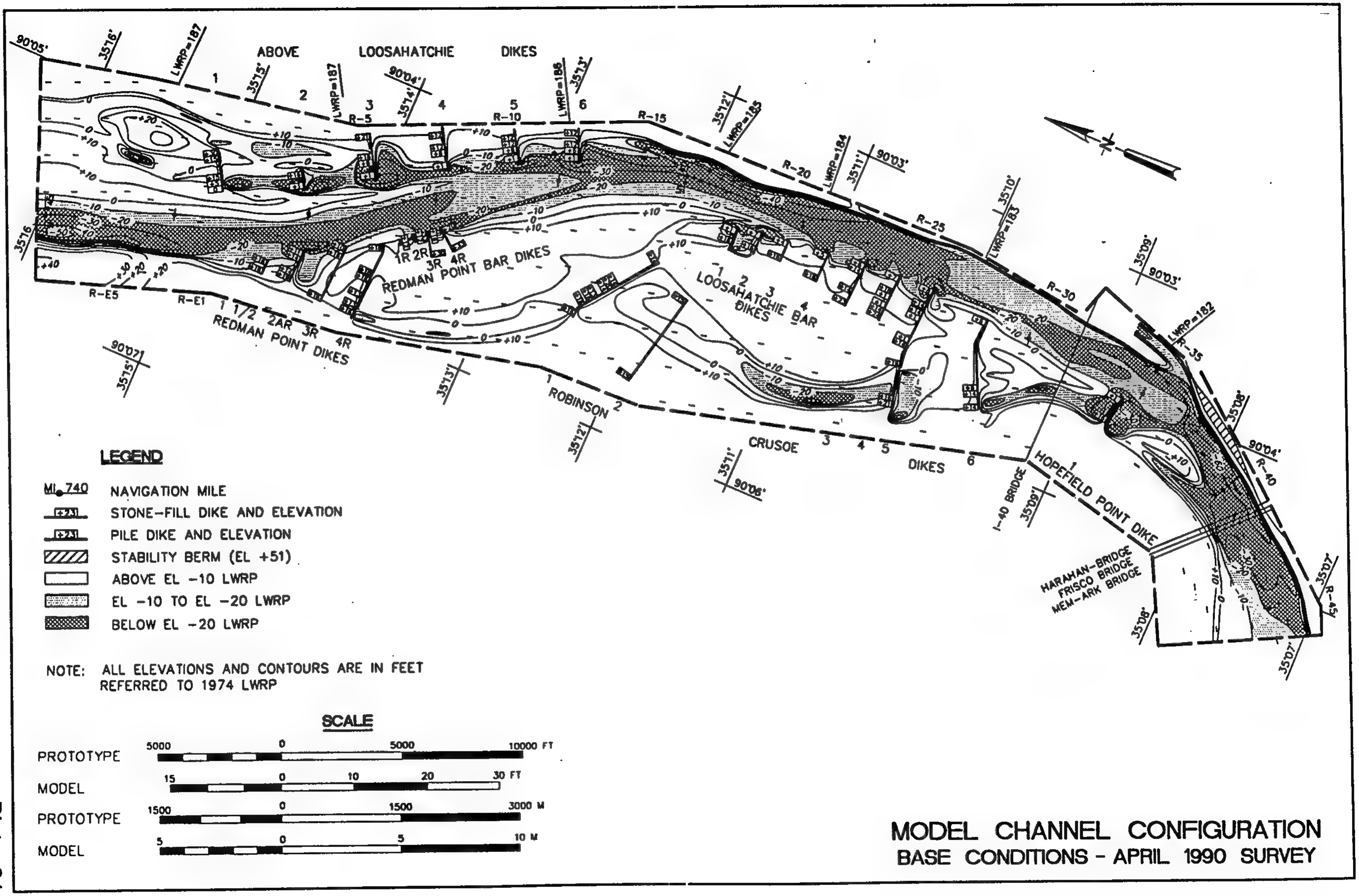


MODEL CHANNEL CONFIGURATION
PLAN C - RUN 2

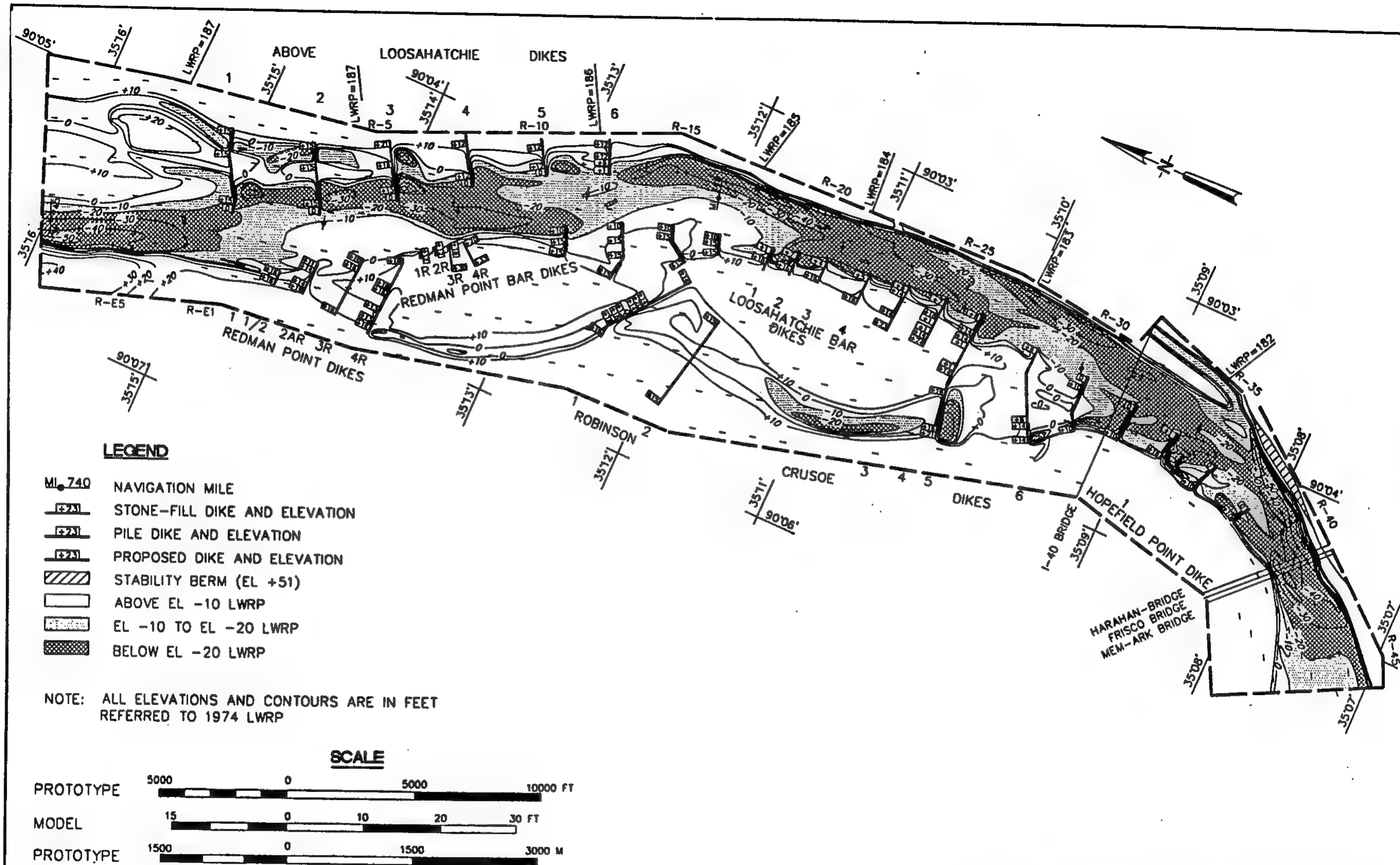


PROTOTYPE SURVEY - APRIL 1990
EXTENDED MODEL

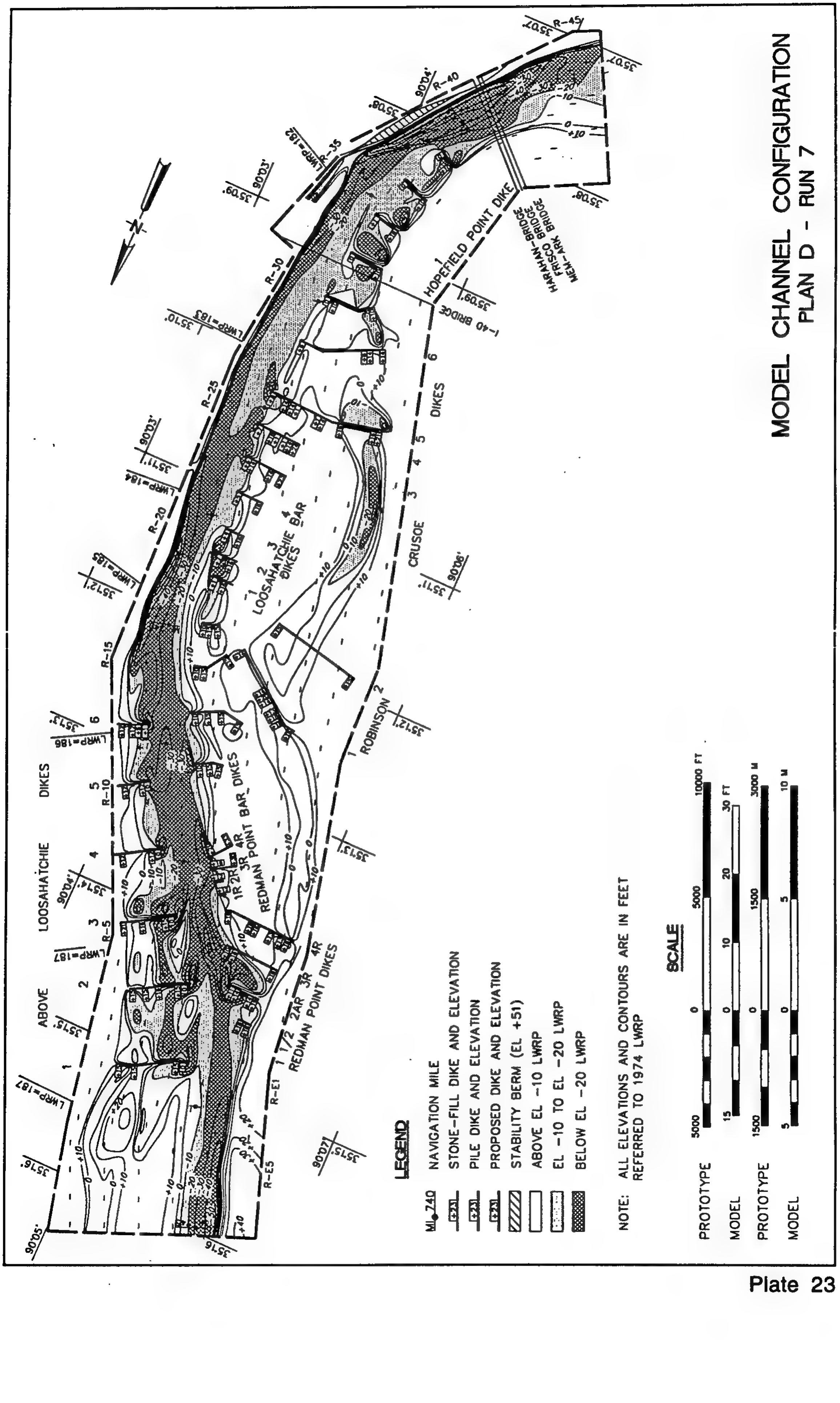
Plate 20

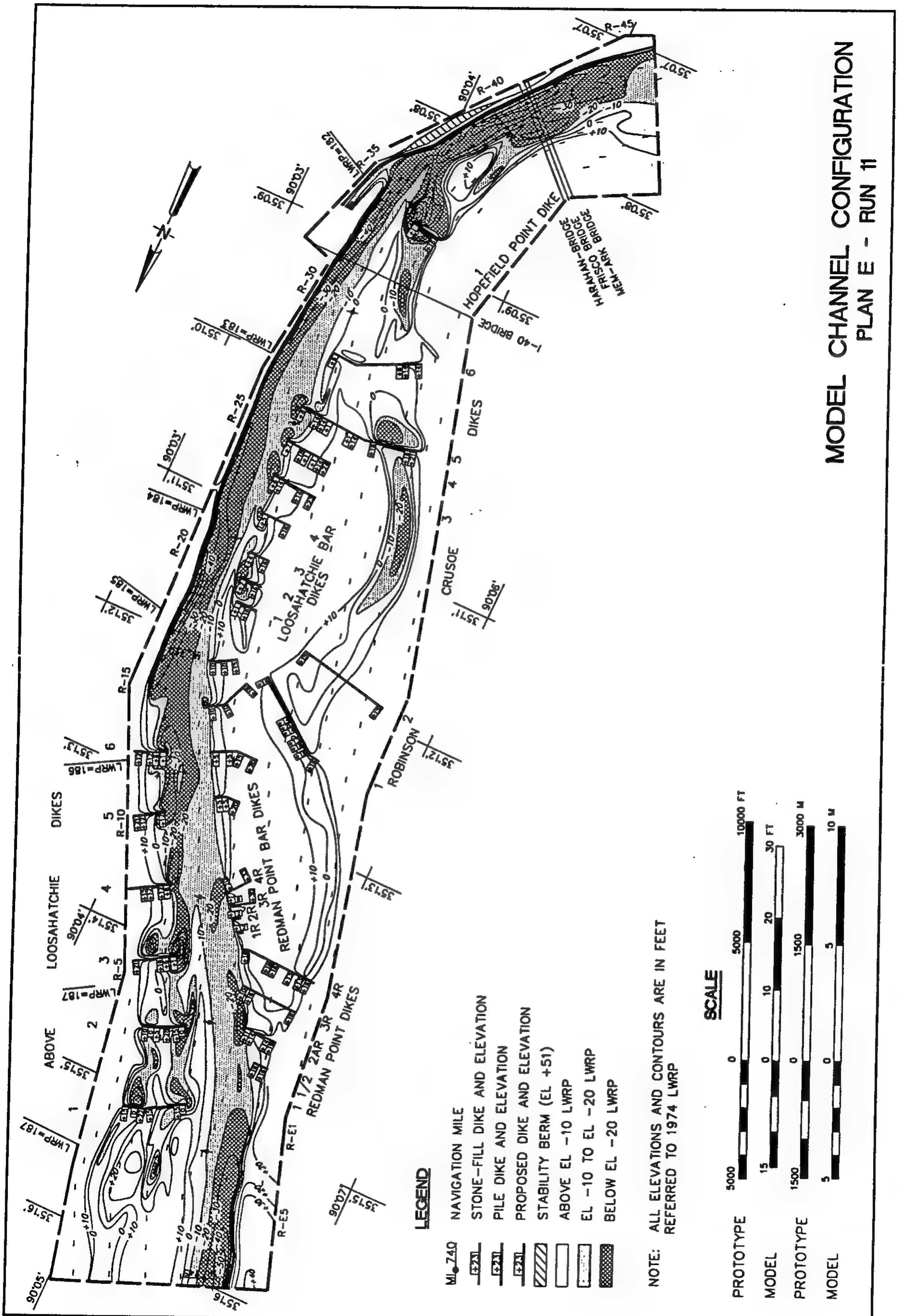


MODEL CHANNEL CONFIGURATION
BASE CONDITIONS - APRIL 1990 SURVEY

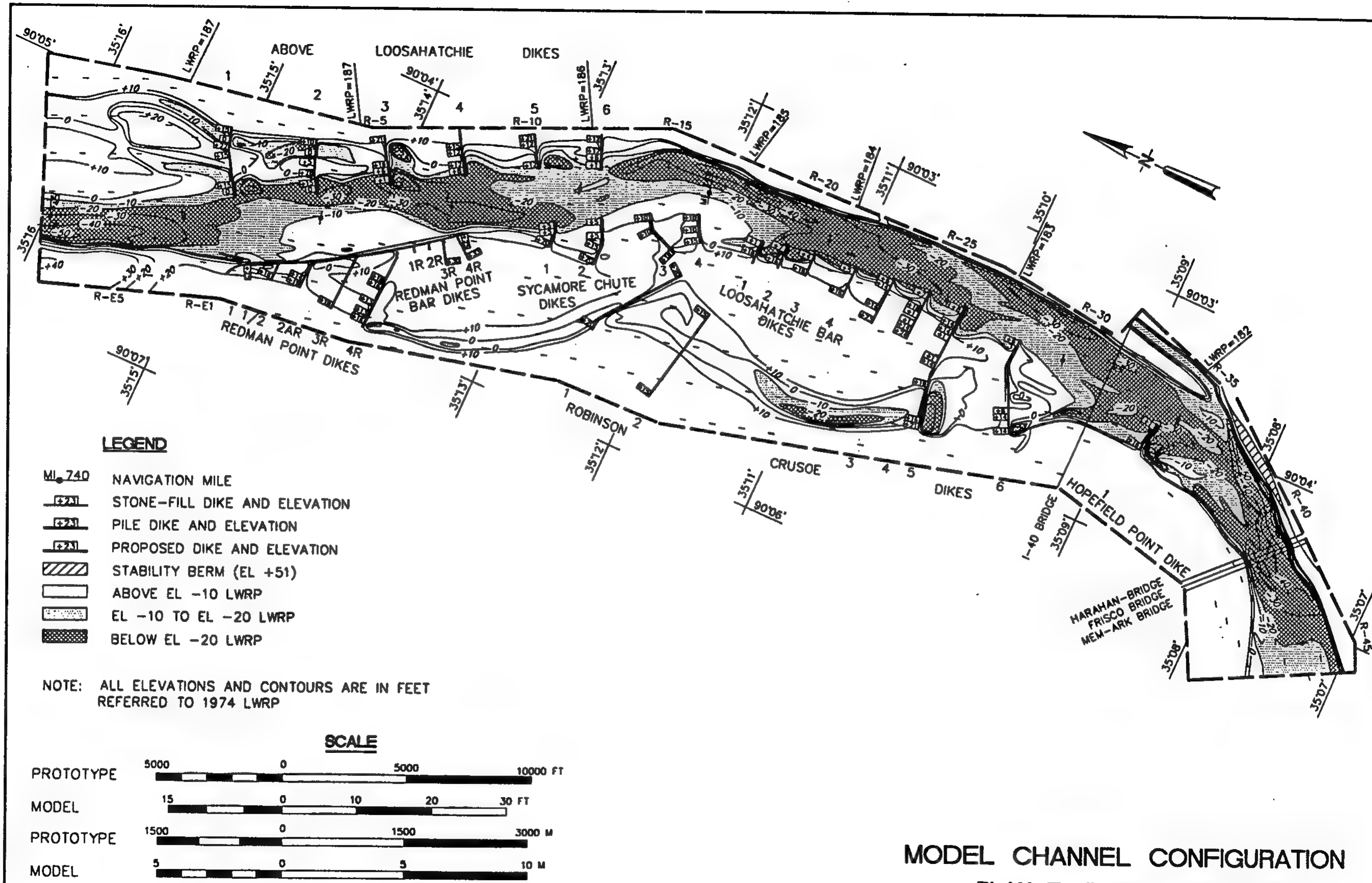


MODEL CHANNEL CONFIGURATION
PLAN D - INITIAL CONDITIONS


MODEL CHANNEL CONFIGURATION
PLAN D - RUN 7
LEGEND
NAVIGATION MILE
STONE-FILL DIKE AND ELEVATION
PILE DIKE AND ELEVATION
PROPOSED DIKE AND ELEVATION
STABILITY BERM (EL +51)
ABOVE EL -10 LWRP
EL -10 TO EL -20 LWRP
BELOW EL -20 LWRP
NOTE: ALL ELEVATIONS AND CONTOURS ARE IN FEET REFERRED TO 1974 LWRP
SCALE
PROTOTYPE 5000 0 5000 10000 FT
MODEL 15 0 10 20 30 FT
PROTOTYPE 1500 0 1500 3000 M
MODEL 5 0 5 10 M
LOOSAHATCHIE DIKES
REDMAN POINT BAR DIKES
REDMAN POINT DIKES
LOOSAHATCHIE BAR DIKES
ROBINSON
CRUSOE DIKES
HOPEFIELD POINT DIKE
I-40 BRIDGE
HARAHAN BRIDGE
FRISCO BRIDGE
MEM-ARK BRIDGE

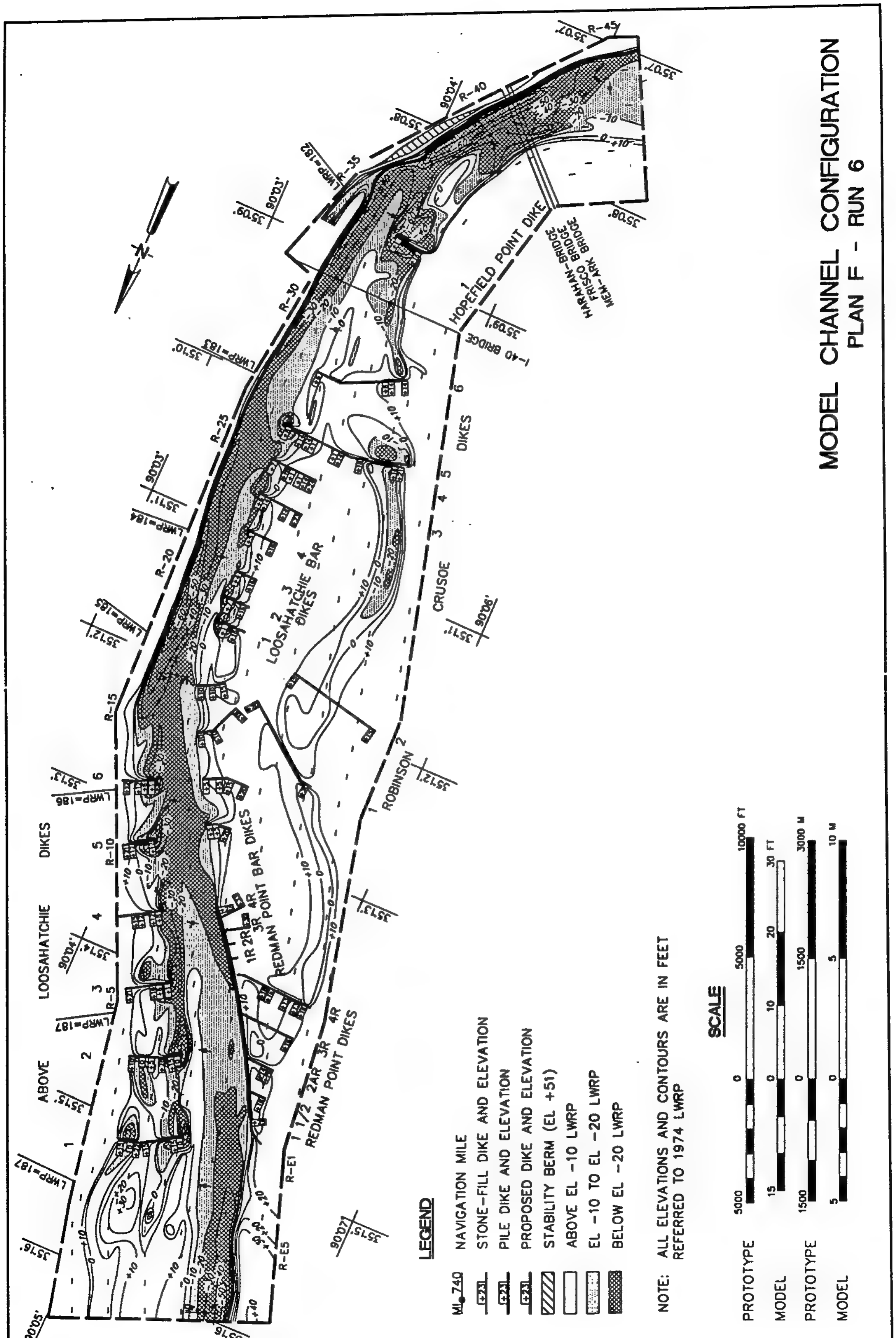


MODEL CHANNEL CONFIGURATION
PLAN E - RUN 11



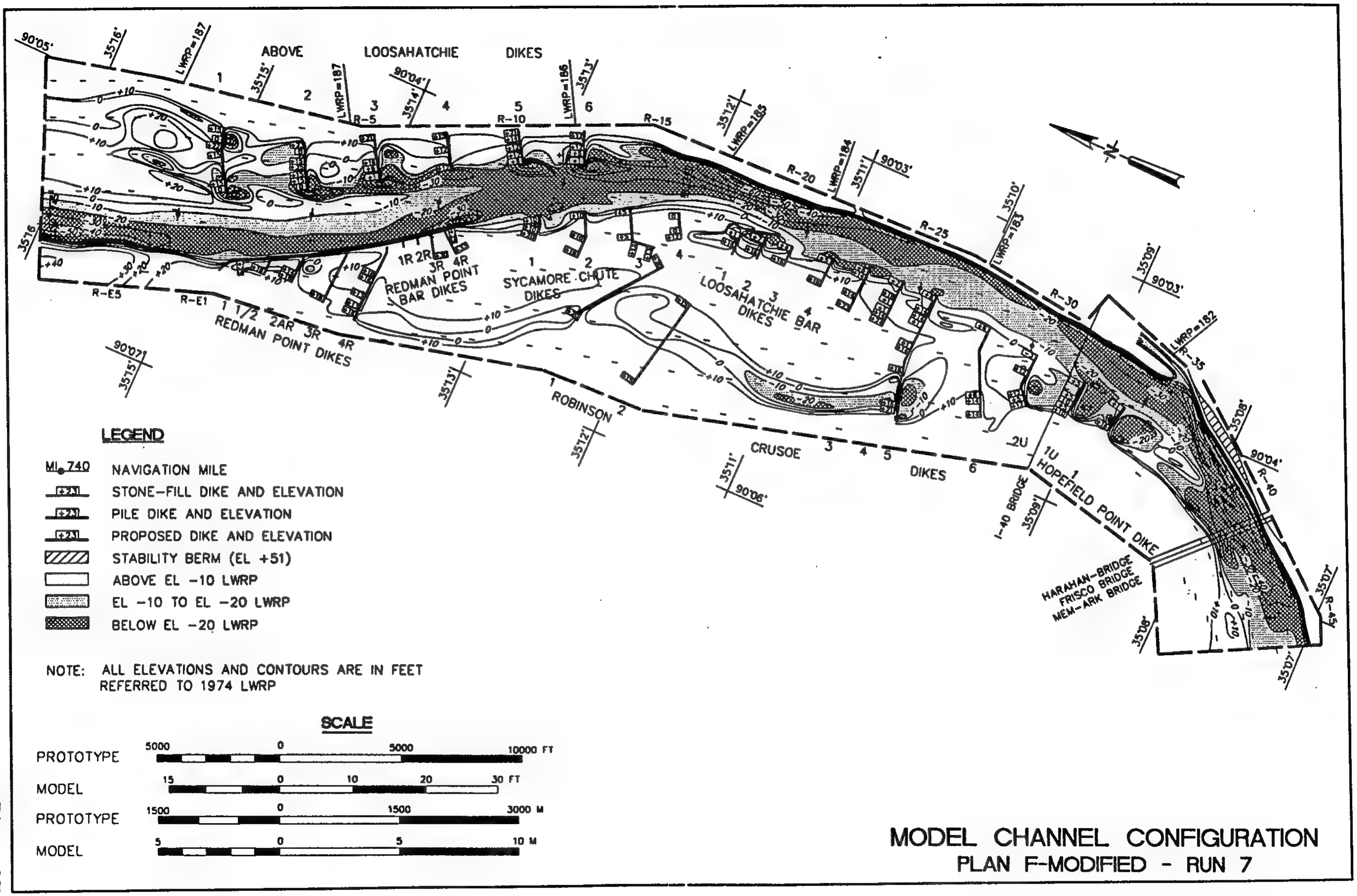
MODEL CHANNEL CONFIGURATION

PLAN F - INITIAL CONDITIONS

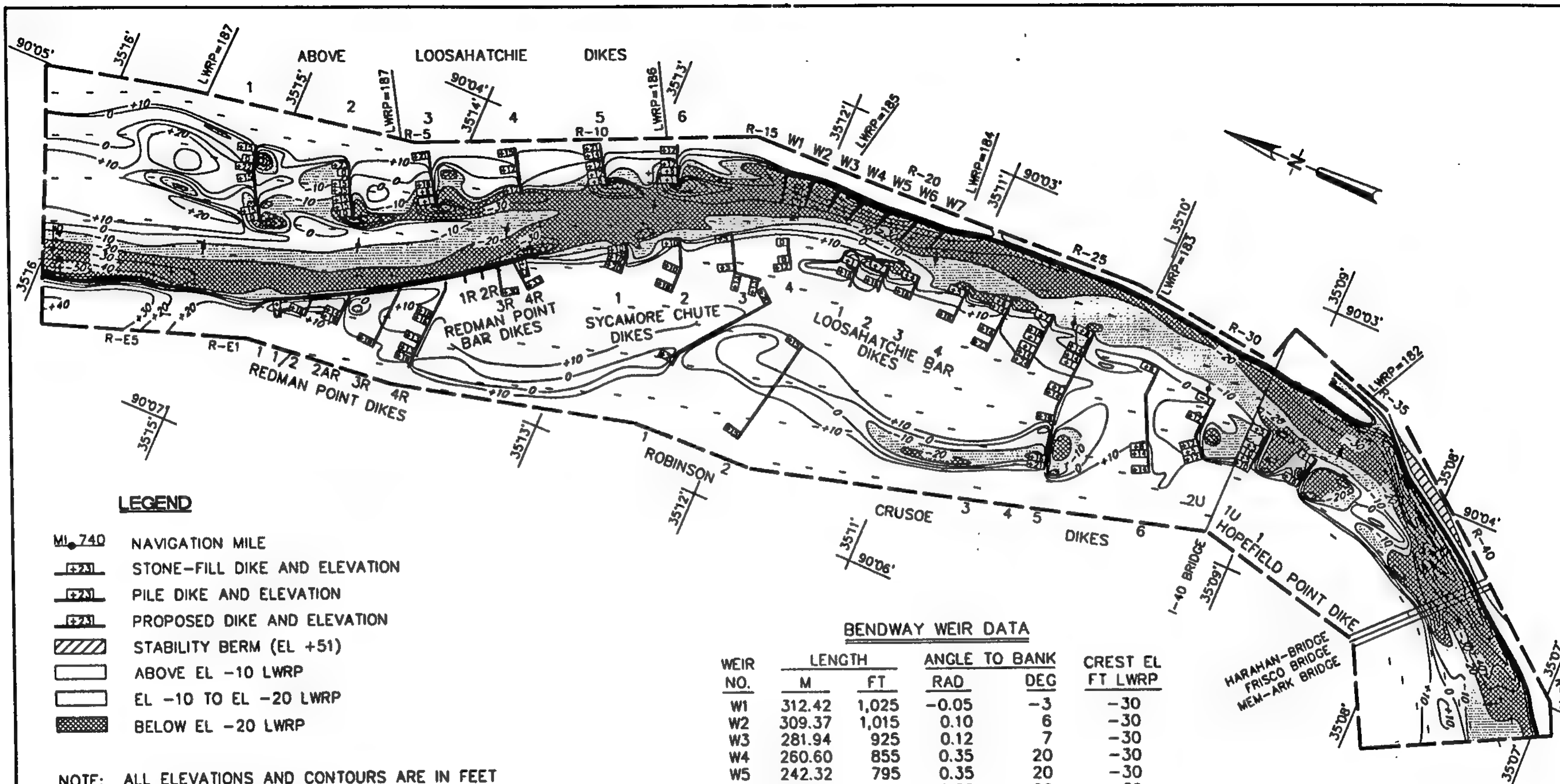


MODEL CHANNEL CONFIGURATION
PLAN F - RUN 6

Plate 26



ABOVE LOOSAHATCHIE DIKES
SYCAMORE CHUTE DIKES
REDMAN POINT BAR DIKES
REDMAN POINT DIKES
LOOSAHATCHIE BAR DIKES
ROBINSON
CRUSOE DIKES
HOPEFIELD POINT DIKE
I-40 BRIDGE
HARAHAN-BRIDGE
FRISCO BRIDGE
MEM-ARK BRIDGE
LWRP=187
LWRP=186
LWRP=185
LWRP=184
LWRP=183
LWRP=182
LEGEND
NAVIGATION MILE
STONE-FILL DIKE AND ELEVATION
PILE DIKE AND ELEVATION
PROPOSED DIKE AND ELEVATION
STABILITY BERM (EL +51)
ABOVE EL -10 LWRP
EL -10 TO EL -20 LWRP
BELOW EL -20 LWRP
NOTE: ALL ELEVATIONS AND CONTOURS ARE IN FEET
REFERRED TO 1974 LWRP
SCALE
PROTOTYPE 5000 0 5000 10000 FT
MODEL 15 0 10 20 30 FT
PROTOTYPE 1500 0 1500 3000 M
MODEL 5 0 5 10 M
MODEL CHANNEL CONFIGURATION
PLAN F-MODIFIED - RUN 7



LEGEND

MI 740	NAVIGATION MILE
+23	STONE-FILL DIKE AND ELEVATION
+23	PILE DIKE AND ELEVATION
+23	PROPOSED DIKE AND ELEVATION
	STABILITY BERM (EL +51)
	ABOVE EL -10 LWRP
	EL -10 TO EL -20 LWRP
	BELOW EL -20 LWRP

NOTE: ALL ELEVATIONS AND CONTOURS ARE IN FEET REFERRED TO 1974 LWRP

SCALE

PROTOTYPE 5000 0 5000 10000 FT

MODEL 15 0 10 20 30 FT

PROTOTYPE 1500 0 1500 3000 M

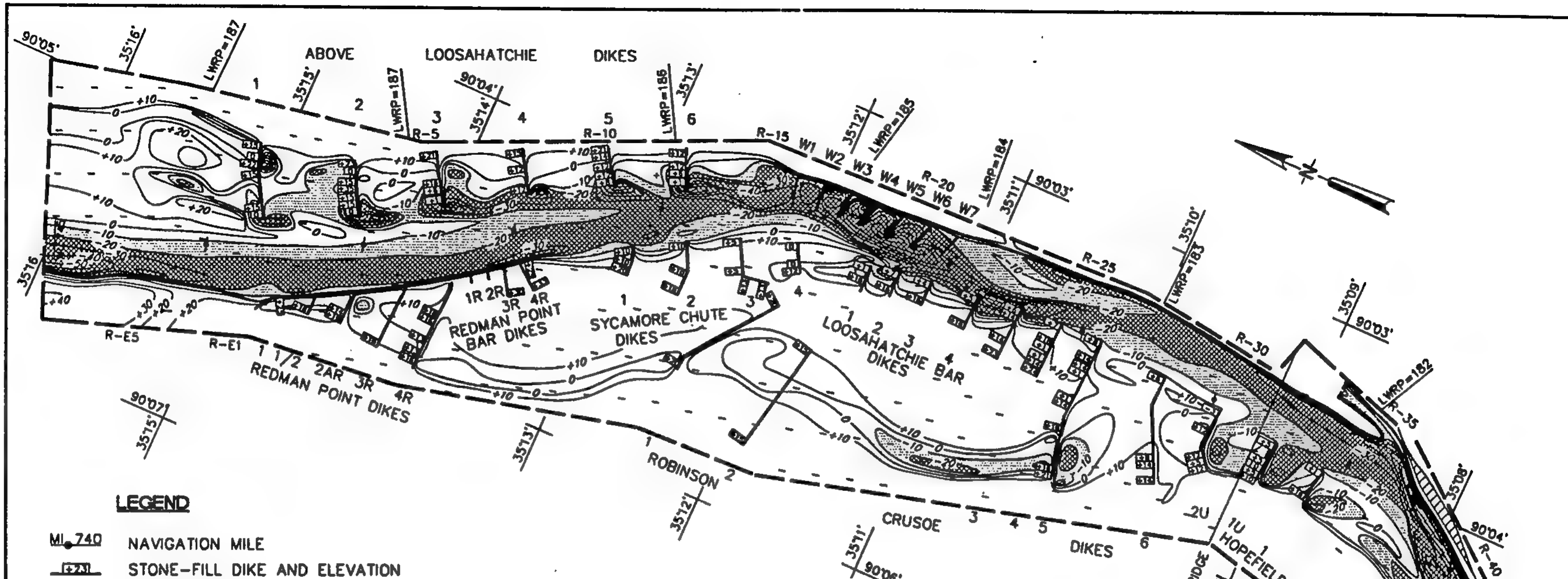
MODEL 5 0 5 10 M

BENDWAY WEIR DATA

WEIR NO.	LENGTH M	LENGTH FT	ANGLE TO BANK RAD	ANGLE TO BANK DEG	CREST EL FT LWRP
W1	312.42	1,025	-0.05	-3	-30
W2	309.37	1,015	0.10	6	-30
W3	281.94	925	0.12	7	-30
W4	260.60	855	0.35	20	-30
W5	242.32	795	0.35	20	-30
W6	289.56	950	0.35	20	-30
W7	251.46	825	0.35	20	-30

NOTE: ALL BENDWAY WEIRS HAD A BANK SPACING OF 304.8 M (1,000 FT).

MODEL CHANNEL CONFIGURATION
PLAN G - INITIAL CONDITIONS



LEGEND

- MI 740 — NAVIGATION MILE
- +23 — STONE-FILL DIKE AND ELEVATION
- +23 — PILE DIKE AND ELEVATION
- +23 — PROPOSED DIKE AND ELEVATION
- STABILITY BERM (EL +51)
- ABOVE EL -10 LWRP
- EL -10 TO EL -20 LWRP
- BELOW EL -20 LWRP

NOTE: ALL ELEVATIONS AND CONTOURS ARE IN FEET REFERRED TO 1974 LWRP

BENDWAY WEIR DATA

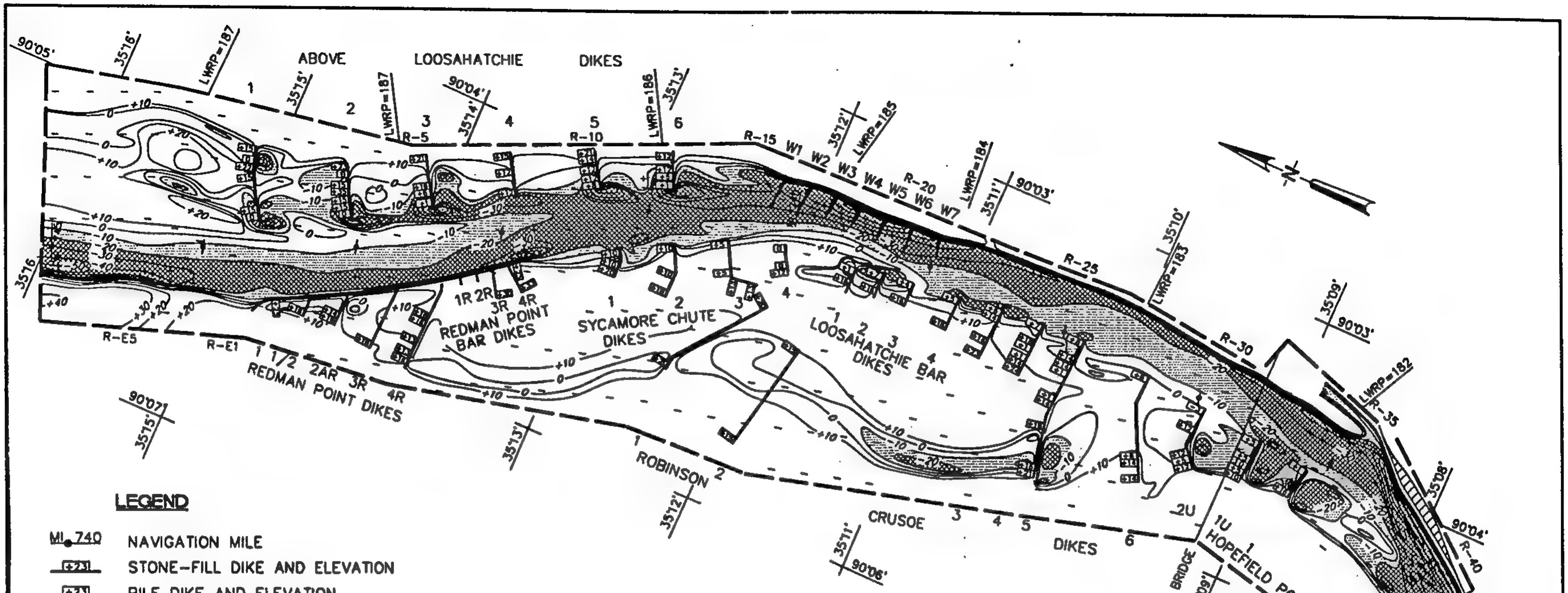
WEIR NO.	LENGTH M	LENGTH FT	ANGLE TO BANK RAD	ANGLE TO BANK DEG	CREST EL FT LWRP
W1	312.42	1,025	-0.05	-3	-30
W2	309.37	1,015	0.10	6	-30
W3	281.94	925	0.12	7	-30
W4	260.60	855	0.35	20	-30
W5	242.32	795	0.35	20	-30
W6	289.56	950	0.35	20	-30
W7	251.46	825	0.35	20	-30

NOTE: ALL BENDWAY WEIRS HAD A BANK SPACING OF 304.8 M (1,000 FT).

SCALE

PROTOTYPE 5000 0 5000 10000 FT
MODEL 15 0 10 20 30 FT
PROTOTYPE 1500 0 1500 3000 M
MODEL 5 0 5 10 M

MODEL CHANNEL CONFIGURATION
PLAN G - RUN 2



LEGEND

- MI 740 NAVIGATION MILE
- +23 STONE-FILL DIKE AND ELEVATION
- +23 PILE DIKE AND ELEVATION
- +23 PROPOSED DIKE AND ELEVATION
- STABILITY BERM (EL +51)
- ABOVE EL -10 LWRP
- EL -10 TO EL -20 LWRP
- BELOW EL -20 LWRP

NOTE: ALL ELEVATIONS AND CONTOURS ARE IN FEET REFERRED TO 1974 LWRP

BENDWAY WEIR DATA

WEIR NO.	LENGTH M	LENGTH FT	ANGLE TO BANK RAD	ANGLE TO BANK DEG	CREST EL FT LWRP
W1	332.23	1,090	0.26	15	-30
W2	320.04	1,050	0.26	15	-30
W3	281.94	925	0.12	7	-30
W4	243.84	800	0.14	8	-30
W5	228.60	750	0.09	5	-30
W6	283.46	930	0.00	0	-30
W7	195.07	640	-0.26	-15	-30

NOTE: ALL BENDWAY WEIRS HAD A BANK SPACING OF 304.8 M (1,000 FT).

SCALE

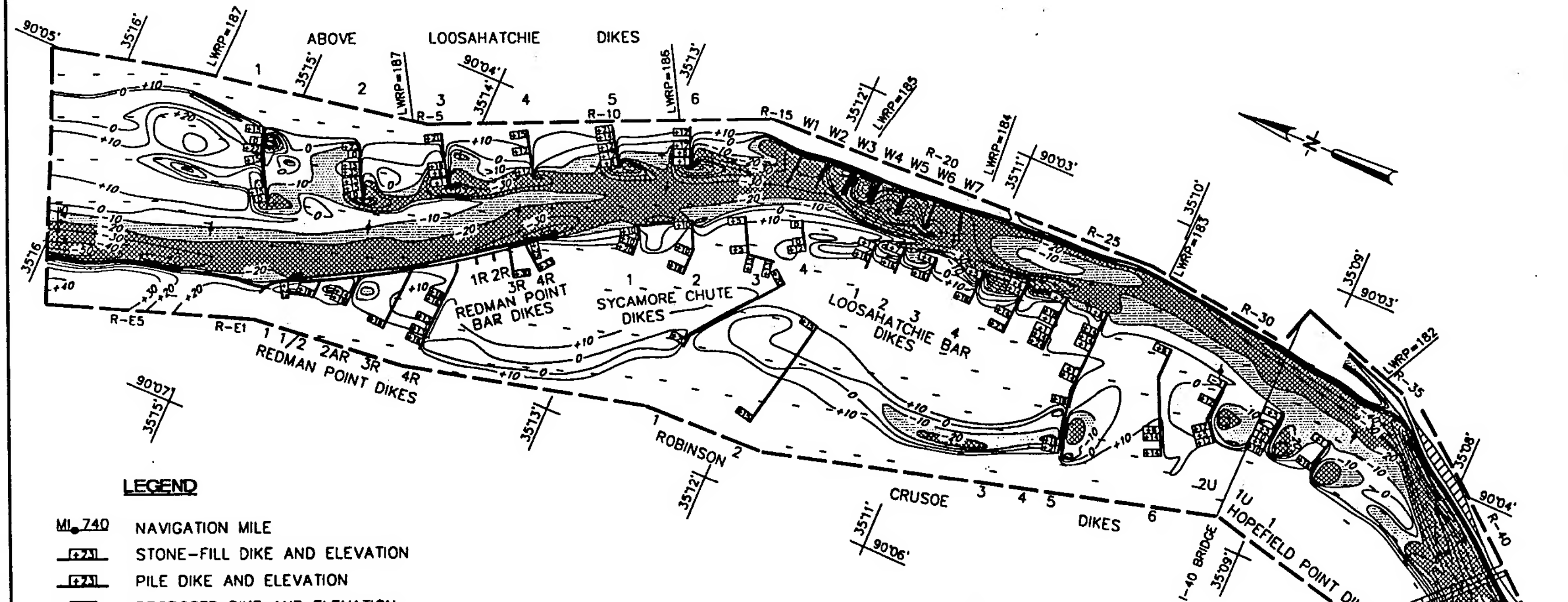
PROTOTYPE 5000 0 5000 10000 FT

MODEL 15 0 10 20 30 FT

PROTOTYPE 1500 0 1500 3000 M

MODEL 5 0 5 10 M

MODEL CHANNEL CONFIGURATION
PLANN G-2 - INITIAL CONDITIONS



LEGEND

- ML 740 NAVIGATION MILE
- +23 STONE-FILL DIKE AND ELEVATION
- +23 PILE DIKE AND ELEVATION
- +23 PROPOSED DIKE AND ELEVATION
- STABILITY BERM (EL +51)
- ABOVE EL −10 LWRP
- EL −10 TO EL −20 LWRP
- BELOW EL −20 LWRP

NOTE: ALL ELEVATIONS AND CONTOURS ARE IN FEET REFERRED TO 1974 LWRP

BENDWAY WEIR DATA

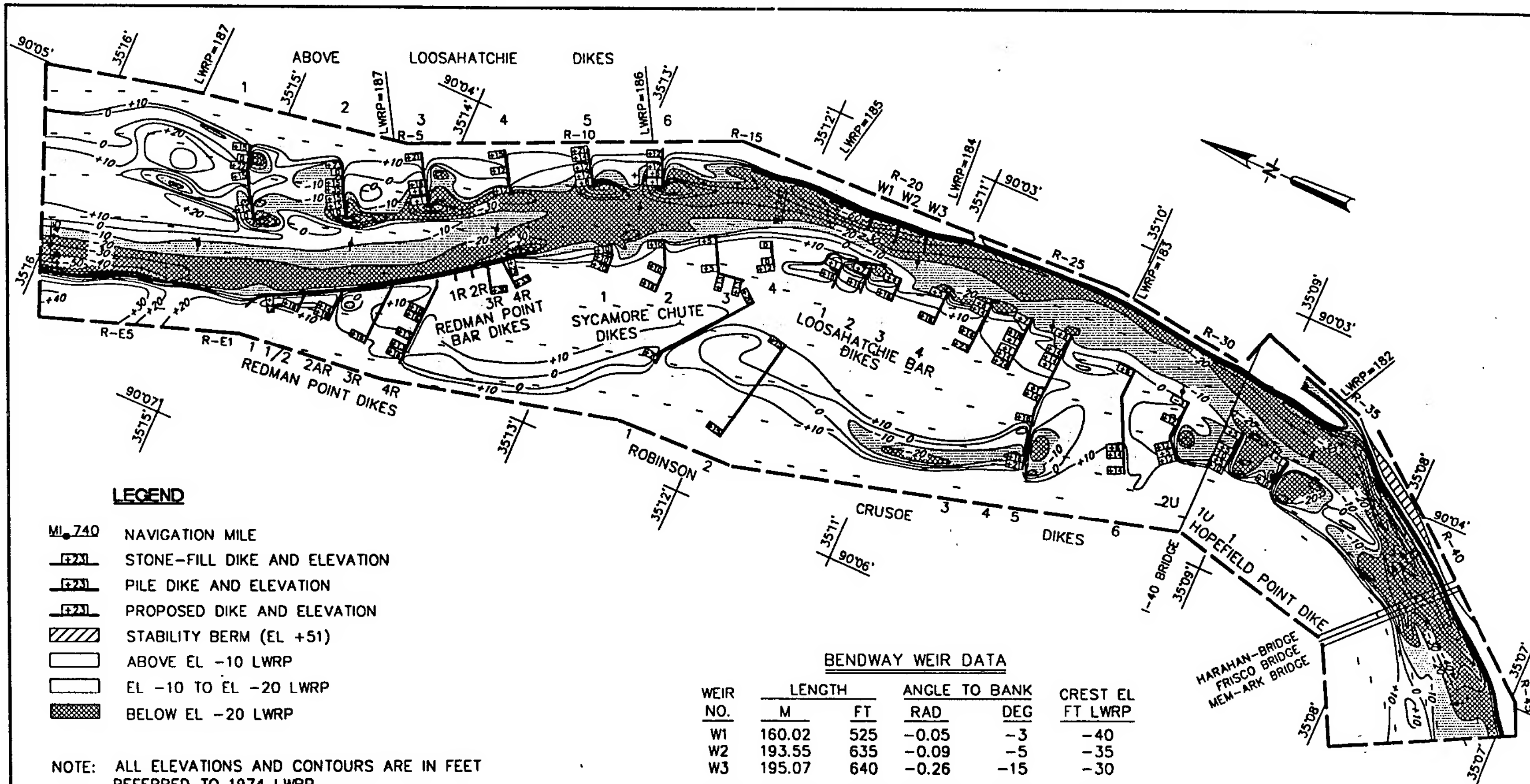
WEIR NO.	LENGTH M	LENGTH FT	ANGLE TO BANK RAD	ANGLE TO BANK DEG	CREST EL FT LWRP
W1	332.23	1,090	0.26	15	−30
W2	320.04	1,050	0.26	15	−30
W3	281.94	925	0.12	7	−30
W4	243.84	800	0.14	8	−30
W5	228.60	750	0.09	5	−30
W6	283.46	930	0.00	0	−30
W7	195.07	640	−0.26	−15	−30

NOTE: ALL BENDWAY WEIRS HAD A BANK SPACING OF 304.8 M (1,000 FT).

SCALE

PROTOTYPE 5000 0 5000 10000 FT
MODEL 15 0 10 20 30 FT
PROTOTYPE 1500 0 1500 3000 M
MODEL 5 0 5 10 M

MODEL CHANNEL CONFIGURATION
PLAN G-2 - RUN 2



LEGEND

MI 740 NAVIGATION MILE

+23 STONE-FILL DIKE AND ELEVATION

+23 PILE DIKE AND ELEVATION

+23 PROPOSED DIKE AND ELEVATION

STABILITY BERM (EL +51)

ABOVE EL -10 LWRP

EL -10 TO EL -20 LWRP

BELOW EL -20 LWRP

NOTE: ALL ELEVATIONS AND CONTOURS ARE IN FEET REFERRED TO 1974 LWRP

BENDWAY WEIR DATA

WEIR NO.	LENGTH M	LENGTH FT	ANGLE TO BANK RAD	ANGLE TO BANK DEG	CREST EL FT LWRP
W1	160.02	525	-0.05	-3	-40
W2	193.55	635	-0.09	-5	-35
W3	195.07	640	-0.26	-15	-30

NOTE: ALL BENDWAY WEIRS HAD A BANK SPACING OF 304.8 M (1,000 FT).

SCALE

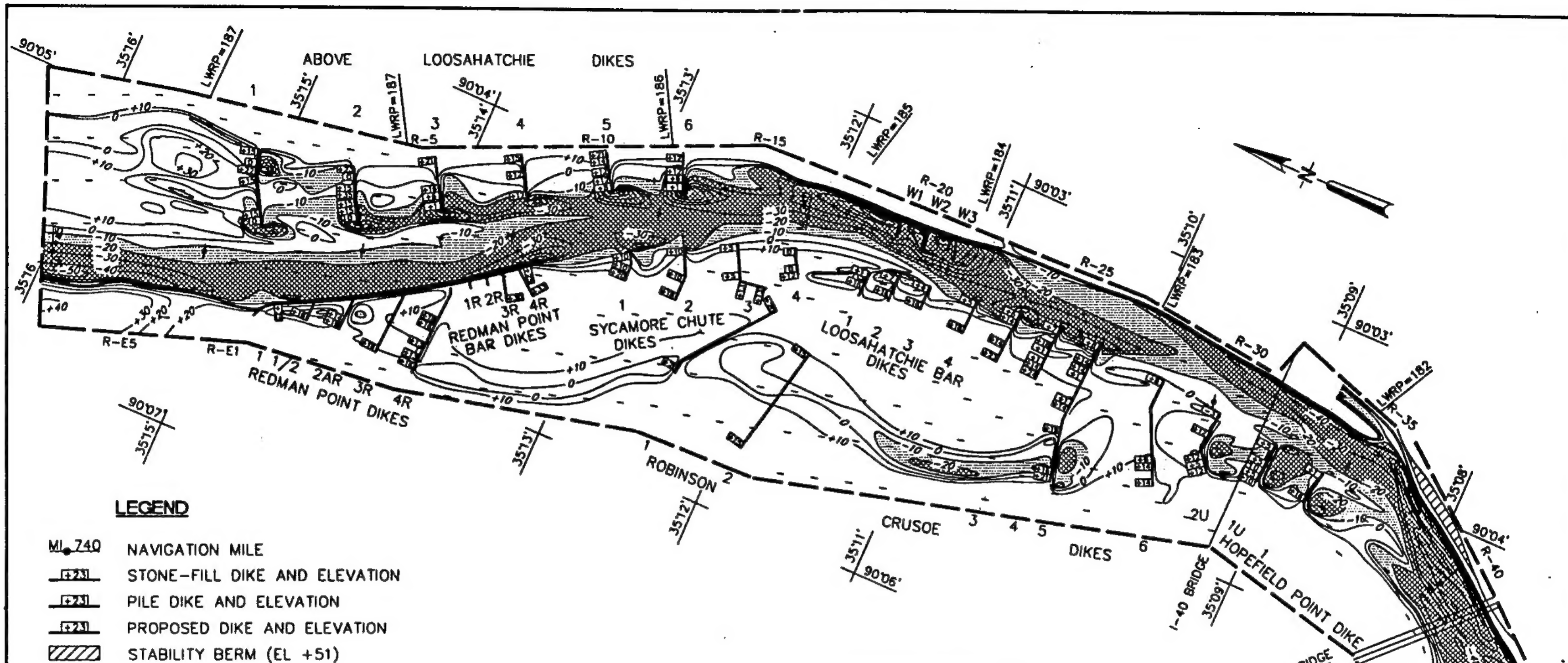
PROTOTYPE 5000 0 5000 10000 FT

MODEL 15 0 10 20 30 FT

PROTOTYPE 1500 0 1500 3000 M

MODEL 5 0 5 10 M

MODEL CHANNEL CONFIGURATION
PLAN G-3 - INITIAL CONDITIONS



LEGEND

- ML 740 NAVIGATION MILE
- STONE-FILL DIKE AND ELEVATION
- PILE DIKE AND ELEVATION
- PROPOSED DIKE AND ELEVATION
- STABILITY BERM (EL +51)
- ABOVE EL -10 LWRP
- EL -10 TO EL -20 LWRP
- BELOW EL -20 LWRP

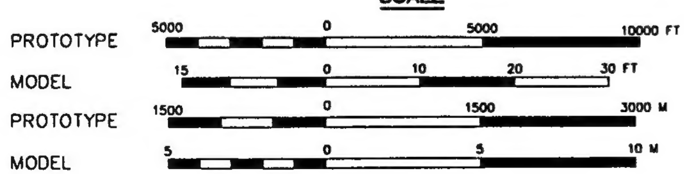
NOTE: ALL ELEVATIONS AND CONTOURS ARE IN FEET REFERRED TO 1974 LWRP

BENDWAY WEIR DATA

WEIR NO.	LENGTH M	LENGTH FT	ANGLE TO BANK RAD	ANGLE TO BANK DEG	CREST EL FT LWRP
W1	160.02	525	-0.05	-3	-40
W2	193.55	635	-0.09	-5	-35
W3	195.07	640	-0.26	-15	-30

NOTE: ALL BENDWAY WEIRS HAD A BANK SPACING OF 304.8 M (1,000 FT).

SCALE



MODEL CHANNEL CONFIGURATION
PLAN G-3 - RUN 2

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13. ABSTRACT *(Maximum 200 words)*

This report describes and gives results of a sedimentation study concerned with the development of improvement plans for the Loosahatchie-Memphis Reach of the Mississippi River, which is located about 740 river miles above Head of Passes. Frequent maintenance dredging has been required to maintain a navigation channel during low river stages in the area upstream of the Interstate 40 Highway bridge, and the left riverbank immediately downstream of Mud Island has a very low stability ratio.

A movable-bed model reproducing approximately 18 km (11 miles) of the river to a horizontal scale of 1:300 and a vertical scale of 1:100 with crushed coal as the bed material was used to develop plans that would improve and stabilize the channel through the reach and the stability of the left riverbank. The model results indicated that an improved channel could be maintained with the proposed dike plan, but that a berm on the left bank would be required to protect its stability.

14. SUBJECT TERMS
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Channel improvement
Dikes (training structures)
Mississippi River
Movable-bed model
Sedimentation
Stability berm

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